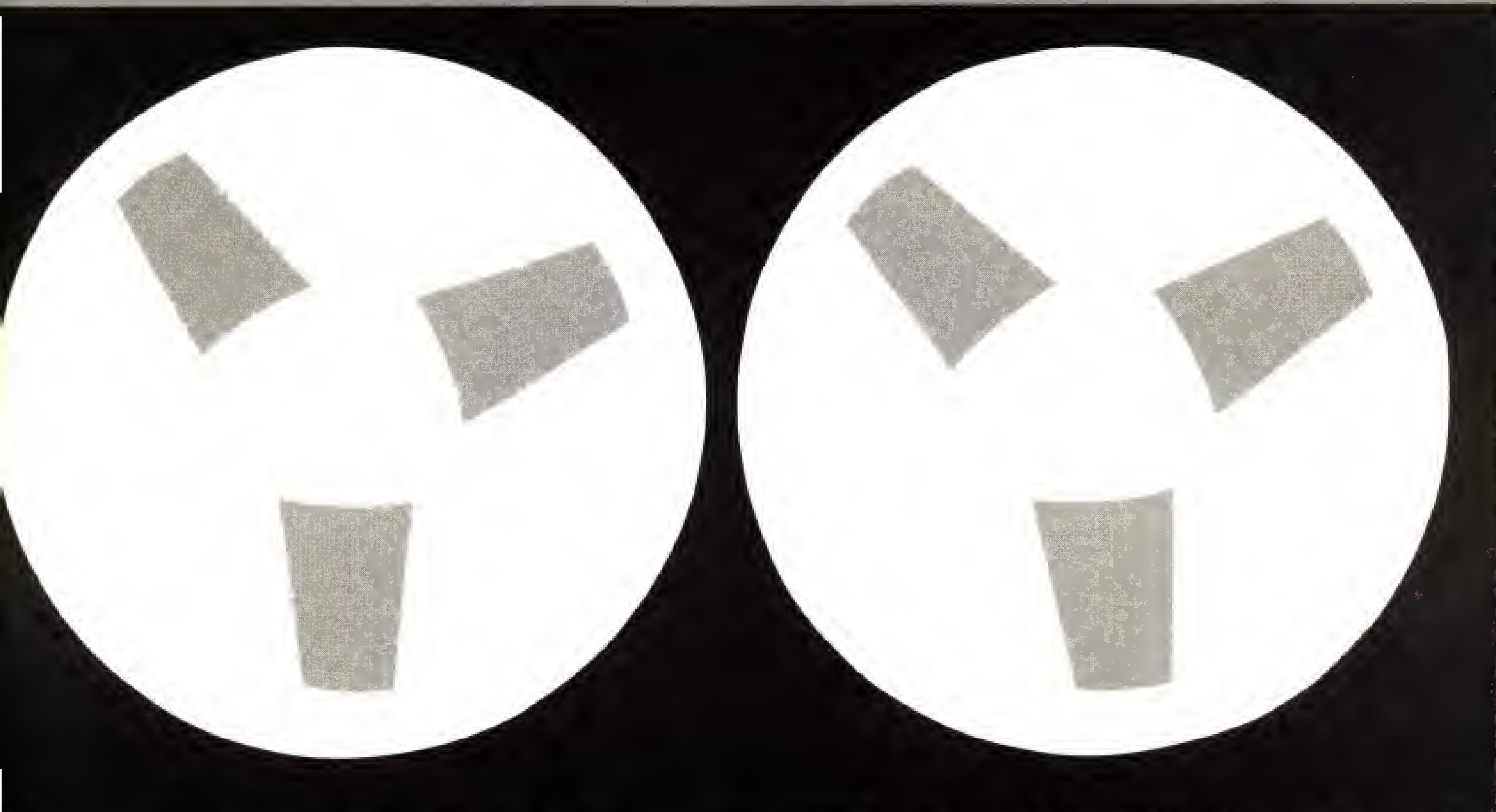
1940

C. R. Doty, Sr.

IBM

TELE-PROCESSING Systems and Equipment



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IBM 'TELE-PROCESSING'* SYSTEMS AND EQUIPMENT

C. R. Doty, Sr.

ABSTRACT

Some notes on the design and application of IBM data transmission equipment from 1940 to 1960.

(*Trademark)

IBM

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IBM 'TELE-PROCESSING'* SYSTEMS AND EQUIPMENT

C. R. Doty, Sr.

SECTION 1

FOREWORD

The transmission of intelligence between two or more points was one of the first problems confronting early man. When distances became so great that the human voice could not span them, signals were produced using smoke, drums and by wigwagging objects.

"This Will Revolutionize Our Communications System"

As men became more widely separated, messages were transmitted by messengers. Later, when the volume of communication increased, the pony express and stage coach were utilized and from this modest beginning our present postal system developed.

The invention of the key and sounder telegraph system by Morse in 1832, the printing telegraph by House in 1836, and the telephone by Bell in 1876 have provided the basic mechanisms on which has been built a system of communication by which it is now possible to exchange information between almost any two points in the world within a few minutes' time.

Through the use of these communication facilities (including both wire lines and radio circuits), IBM has pioneered in the transmission of data, starting in 1941 with the introduction of automatic machines to produce telegraphic tapes from punched cards and punched cards from telegraphic tapes, and subsequently, in 1954, with the introduction of the Data Transceiver which for the first time provided direct card-to-card transmission.

The purpose of these notes is to bring together under one cover some of the pertinent facts regarding the development of data transmission equipment by IBM. Several write-ups are included showing the application of our products in both military and commercial uses. This general class of products is now known as TELE-PROCESSING equipment.

These notes deal only with data transmission equipment in which the writer has been involved in either the development or the development and application.

SECTION 2A

CARD-TO-PAPER TAPE AND PAPER TAPE-TO-CARD TRANSMISSION

GENERAL

Since the development of automatic card-to-tape and tape-to-card machines by IBM in 1941, it is no longer necessary to physically associate the source document and the card punching means. The medium by which the document and the card punching are coordinated is the perforated paper tape. Paper tape is used extensively for controlling printing telegraph machines for the sending of messages, distribution of press information to newspapers, and many other important uses. It is, therefore, an ideal medium for transferring card intelligence from one point to another because the data are capable of being telegraphed. Only five-hole telegraphic tape is covered in these notes because it is the only format which can be telegraphed universally.

In the five-hole code the requirement exists for distinguishing between alphabetical and numerical data because there are only thirty-two combinations of five. Of these thirty-two combinations, twenty-six are used for alphabetical designations, five combinations are required for spacing, carriage returning, paper feeding, and the letters and figures designations, and one combination is not used. Appendix A shows the five-hole Baudot code. The twenty-six codes used for alphabetic characters are also used for figures and special characters. For example, the two-three combination of holes is either the letter I or the numeral 8 depending upon whether it is preceded by a letter or a figure shift control code.

The holes are punched in the tape from top to bottom in the same manner as IBM cards are punched. Each column of tape represents a character just as each column of a tabulating card represents a character. The standard single roll of tape is eight inches in diameter and contains one thousand feet of paper. At ten characters to the inch, which is the standard spacing, one roll of tape will accommodate 120,000 characters or approximately 1,500 fully punched, eighty column IBM cards.

The modern printing telegraph got its start in 1910 with the development by Krum of the start-stop method of synchronizing the transmitting and receiving machines. In the 1920's, printing telegraph machines became widely used for the transmission of commercial telegrams and the dissemination of news by the press agencies. Another early use of the machines was in 1928 for the exchange of information pertaining to the operation of the trans-Atlantic telephone. In this application, the machines were operated by radio between New York and London.

During the 1930's, printing telegraph machines began to be applied to many of the problems of business in which the rapid exchange of information was important. Banks installed the machines so that they could keep abreast of the rapidly changing state of foreign affairs and politics which affected the financial situation; thousands of miles of wire were used to connect some 250 weather stations throughout the country, principally for the distribution of information for the dispatching of planes; many commercial businesses installed the machines to speed order writing between the office and factory; railroads used them to transmit information about car loadings so that trains could be handled more expeditiously upon arrival at the next terminal; and police departments in practically all key cities in the United States were connected together for the distribution of crime information.

The number of miles of private telegraph channels in service in 1941, 1945 and 1960, as well as the approximate number of telegraph machines in private wire service, are shown in the following tabulation:

A. T. & T.

(Long lines only as figures for associated Bell System Companies are not readily available.)

	1941	1945	1960
Approximate Airline Miles of Private Wire Telegraph Channels	395,000	837,700	3,725,000
Approximate Number of Telegraph Machines of all Types	2,495	4,400	30,300

Western Union

	1941	1945	1960
Approximate Airline Miles of Private Wire Telegraph Channels	363,000	457,400	3,020,000
Approximate Number of Telegraph Printers	950	1,350	16,500

While the transmission rate is low (6 - 10 characters per second), the cost is low compared to a telephone channel. The telegraph channels which are used for this purpose are known as "private wire" channels and are usually rented on a monthly basis for a minimum of eight hours per day, five days per week.

Where a printed record of the data transmitted is desired, a telegraph printer can be used. The printing can take the form of a listing, or a document such as an invoice. The data can be sent to two or more points simultaneously (broadcast) and the end result at any location can be hard copy or tape, or both, as may be required.

Transmission over telegraph circuits are at a speed fixed by the characteristics of the channels and the operating speed of the communication equipment— tape readers, tape punches and printers. Three speeds are available when transmission is controlled by perforated paper tapes, 6, 7-1/2 or 10 characters per second.

When IBM cards are to be reproduced by telegraph, two machines are required, one to create the transmittal tape and the other to punch the cards from the duplicate tapes produced at the receiving end of the circuit. The first two machines developed for this purpose were known as IBM 57 and 40. They are described briefly below.

The IBM 57 Card-Controlled Tape Punch, a transmitter, was built around an IBM 54 Verifier, by adding to that machine a tape-punching attachment. As the cards passed under the reading brushes of the Verifier, each column was read to determine if the information recorded therein was alphabetical, numerical, or if the columns were unpunched. By means of relays, the tabulating code was converted to the five-hole telegraphic code which was then punched in the tape. The first production machine was shipped from Endicott in February 1942.

The IBM 40 Tape-Controlled Card Punch, a receiver, read the perforated tape and controlled relays which changed the telegraphic five-hole code into the tabulating code, which was then punched into cards. The 40 machines was composed of a tape reading attachment to an IBM 31 Alphabetical Duplicating Punch. The first production machine was shipped from Endicott in July 1941.

More complete information on these machines will be found in Appendixes B and C.

Between 1941 and 1945 the IBM 57 and IBM 40 machines were used by the military in a wide variety of applications.

The ability to reproduce punched cards over the telegraph circuits was of tremendous value to the logistics operation of the armed forces during World War II. Writing in Army Ordnance magazine for January-February 1943, Major General Davison Olmstead had this to say about the marriage of business machines and telegraph facilities:

"The War Department Signal Center is, of course, only one unit of a network which reaches around the world by wire and radio. This network is outstanding

in the speed with which words are transmitted and received. A great deal of the transmission is fully automatic; not only have we made complete use of the Teletypewriter on wire circuits, but we have found that even more rapid transmission can be obtained with the radio-operated typewriters. In certain parts of the Army communication system, the principles of automatic business machines have been adapted to operation at a distance. We actually can do bookkeeping by wire and thus keep an automatic record in a central office of inventories and other accounting facts which have their physical reality at a remote warehouse or depot."

In his notes on IBM activities in World War II, Mr. R. E. Duncan wrote as follows on the subject of Logistics of Global War:

"All of the Army Supply Services used IBM electric accounting machines for stock control at the depot level, and in conjunction with this program there was developed a completely integrated system of telegraphic stock-balance control procedures with the use of IBM card-to-tape and tape-to-card machines. Beyond a doubt, this one application of the punched-card principle in a time of national emergency will go down in history as IBM's greatest single contribution to the successful prosecution of the war. Military men readily concluded that the successful handling of global logistic operations was in large measure due to the efficient operation of these interconnected stock accounting systems. This and the weekend shipments of IBM machines in April 1942 were two of the principal factors responsible for the successful coordination of the whole wartime supply mission of the Army. No other single phase of war activity was of greater importance in shortening the duration of the war."

For approximately the last two years of the war, the volume of punched card data transferred from point to point by telegraph is estimated at 4,000,000 to 5,000,000 cards per month.

Since the close of the war in 1945, the machines have been put to use in a wide variety of commercial applications. Whereas they had been used essentially for making duplicate cards by telegraph during the war, post war commercial uses included a number of automatic form-writing applications. These forms include invoices, railroad interchange reports and train consists, brokerage confirmations, and others.

Starting in 1946, new models of the card-to-tape and tape-to-card machines were produced at Endicott. These were known as the 60 and 42 respectively. Endicott also produced several IBM 41 Tape-Controlled Printing Punch machines for the New Haven Railroad.

As our activity in the commercial field increased, and our machines were applied to more varied applications of industry, it became increasingly clear that they were not sufficiently flexible and that unless new designs (in which all circuits and machine functions were under operator control through the

use of a control panel) were undertaken, we would be faced with a situation in which the machines would have to be custom-built for each installation. This resulted in the development of the IBM 63 card-to-tape and the IBM 43 tape-to-card machines in 1949. Subsequent to this the IBM 46 and 47 tape-to-card machines were developed. The 46 and 47 (non-printing and printing respectively) were capable of reading either five or eight hole tapes.

The following tabulation shows the number of machines of each type which have been shipped to June 1960. Three of these machines are pictured on pages 8 and 9.

	Manufactured		Machines Shipped			
Type	From	To	New	Rebuilt	Recon.	Total
Card-to-Tape						
57	2/1942	3/1949	209	2	23	234
60	10/1946	2/1949	87	6	3	96
63	2/1950	6/1960*	1155	610	14	1779
			1451	618	40	2109
Tape-to-Card						
40	8/1941	10/1946	133	0	20	153
41	7/1945	2/1951	18	14	0	32
42	6/1947	4/1949	43	1	0	44
43	11/1949	11/1955	415	2	36	453
46-47	2/1954	6/1960*	2435	0	368	2803
			3044	17	424	3485

* The IBM 63 and 46-47 machines are still in production at Poughkeepsie. The 46-47 machines accommodate both five and eight hole tape. No data are available as to the exact number used in each application.

The number of machines installed as of April 1, 1960 is as follows:

Card-to-tape	Type 63	1178
Tape-to-card	Types 46-47	1872
	Total	3050

Assuming that 1200 IBM 46-47 machines are used in five-hole tape applications, the current annual rental derived from these machines in data trans-

The IBM 63 Card-Controlled Tape Punch

The IBM 43 Tape-Controlled Card Punch

The IBM 46 Tape-to-Card Punch

mission applications is approximately $3, 100, 000.

The remainder of Section 2 is devoted to the development history of card-to-tape and tape-to-card machines, description of some typical applications, and a listing of the patents which have been granted to the writer on paper tape equipment. The descriptions include the Office of Defense Transportation; The New York, New Haven & Hartford Railroad; Merrill Lynch, Pierce, Fenner & Smith, and Vanity Fair Mills.

In the case of the New York, New Haven & Hartford Railroad (Section 2D) the installation has led to the adoption of tape equipment on many other railroads. On connecting lines, such as the Erie and Pennsylvania, the interchange of information in tape or card form has resulted in a considerable saving in both time and money over the former system of transcribing written records to punched cards. The basic system installed by the New Haven in 1945 is still in use today with the exception that the "final" inbound consist has been discontinued.

In the case of Merrill Lynch, Pierce, Fenner & Smith (Section 2E), people like to deal with the firm that renders the best service. The jump that Merrill Lynch got on the other brokers by reason of telegraphing confirmation forms

was almost immediately apparent and orders were forthcoming from most of the large brokerage houses for card-to-tape machines to enable them to operate on a competitive basis. Among the firms to make similar installations were Harris, Upham & Company, and Thomson McKinnon. Business Machines for October 6, 1949 contained the following statement:

"A number of firms throughout the nation have adopted the IBM method for billing operations in brokerage transactions. Many more have placed orders for IBM equipment.

"The use of the IBM card-to-tape machines in conjunction with commercial wire transmission has solved the problem of distance in accomplishing local mailing of customers' bills the same day that the transaction takes place."

In addition to providing better service, the system resulted in the saving of considerable money for the broker. Merrill Lynch released a description of their operation, which was printed by American Business Magazine in August, 1949 and in Business Machines for October 6, 1949, in which they claimed that the centralized bookkeeping system resulted in a saving of a million dollars a year.

The basic system of telegraphing confirmation forms is still in use at Merrill Lynch. A total of 130 offices now receive forms in this manner. The IBM card-to-tape machines have been replaced by a Digitronic magnetic tape to paper tape converter because the data to be transmitted are now recorded on magnetic tape rather than punched into cards.

SECTION 2B

DEVELOPMENT HISTORY AND WORLD WAR II APPLICATIONS

The National Analine Company was the first organization to approach IBM (Commercial Research Department files) regarding the possibility of making machines which would punch tabulating cards automatically from the holes punched in paper tape as used to control A. T. & T. and Western Union printing telegraph equipment. A conference was held at their offices on May 7, 1940 at which time the proposal was discussed in detail.

In November and December of the same year similar inquiries were received from Courts & Company (investment securities) and Owens-Illinois Glass Company.

In December 1940 specifications for a tape-to-card punch were submitted to the Engineering Department at Endicott.

The imminence of World War II and the realization on the part of the military logistical planners that the speed and accuracy of transferring personnel records, reporting stock balances and handling many other items of a principally statistical nature, would have to be greatly improved to meet the requirements of modern warfare, led to inquiries by the Air Corps as to the possibilities of developing a machine which would read the holes punched in telegraphic paper tape and transfer the data to IBM cards automatically. The purpose of this machine was to avoid the laborious and inaccurate manual transcription of information from the telegraphic printed lists to IBM cards at the receiving point. They were informed that the matter had already been given consideration and that such a machine appeared to be practical.

At the request of the Air Corps, a meeting was held at Wright Field, Dayton, Ohio, on February 13, 1941, at which A. T. & T. and IBM were represented. Mr. L. H. LaMotte, the writer, and representatives of the Dayton office comprised the IBM group. It will be noted that this meeting followed the National Analine inquiry by almost a year, and that specifications for a machine to accomplish automatic card punching were already in the hands of the Engineering Department. As IBM had previously informed Wright Field that it appeared practical to develop a machine to meet their requirements, the purpose of the meeting was to confirm their understanding, and to decide whether IBM, A. T. & T. or both companies jointly would undertake the development. After some discussion, it was agreed that A. T. & T. responsibility would end when the tape was perforated, and that IBM would undertake the machine development. A. T. & T. was therefore not involved in any part of the development program of this machine but its representatives were most cooperative and helpful in the dissemination of data regarding their equipment and line circuits.

It was brought out at the meeting that the A. T. & T. machines and circuits were in the process of installation and were scheduled for completion April 1.

It was requested that IBM proceed with all haste to produce a trial machine. The model machine was completed and installed at Wright Field on a test basis on May 12-14, 1941, just three months after the date of the meeting.

At the same meeting the desirability of developing a machine which would automatically prepare telegraphic tape under control of punched cards was also advanced. Such a machine would avoid the laborious and inaccurate manual punching of telegraphic tape from documents prepared from punched cards at transmitting points.

On June 12, 1941, the specifications for a card-to-tape punch were discussed at Wright Field. On June 27, 1941, we were informed by Mr. McCann of Bell Telephone Laboratories that A. T. & T. would be willing to accept tapes punched by IBM equipment for control of their Teletypewriters. Specifications for the card-to-tape punch were immediately released to the Engineering Department.

The first model card-to-tape punch was tested at Wright Field on November 24-26, 1941.

Tests of the tape-to-card machines by the Air Corps proved them to be satisfactory and an order was placed for ten machines. These ten machines (the first production lot of the IBM 40) were shipped to the Air Corps at Wright Field in August 1941. After the machines had been in service for several months, the Air Corps furnished information to the Dayton Daily Times about their application and advantages. Appendix D is the complete press release dated December 1, 1941. In summary, this release points out that prior to the use of these machines, once-a-year balances of equipment in Air Corps depots throughout the U. S. were reported to materiel division headquarters at Wright Field, where they were transcribed to tabulating cards. The article states that the new equipment facilitates the keeping of daily balances and performs a job which would be physically impossible under the old system. Through the new system 40,000 changes a day in balances on some 300,000 individual stock items were processed.

Between February and August 1942, the first ten card-to-tape machines (IBM 57's) were shipped to the Air Corps.

As the wartime military forces of the United States grew in size and were deployed over wide areas both at home and overseas, the need for an orderly and speedy method of assembling and transmitting reports to higher headquarters became of paramount importance. The automatic IBM card-to-tape and tape-to-card machines were often employed where there existed a neces-

sity for rapidly assembling and consolidating punched-card source data from distant and scattered points of origin.

Beginning with an initial installation for the Air Materiel Command in May 1941, the Air Corps network increased in size until in 1943 and 1944 it comprised eleven regional control offices besides a central office at Wright Field, Dayton, Ohio; two in-transit depots located at ports of embarkation; and a subsidiary system of leased-wire networks to lesser Air Corps depots. Using the IBM card-to-tape and tape-to-card units, the Air Technical Service Command, with headquarters at Wright Field, exercised management control over all tactical bases and supply depots in the continental United States.

The excellent results obtained by the Air Corps with these machines led to their use during the war by various other branches of the Armed Services, such as the Quartermaster Corps, Signal Corps, the Army Ordnance Department, the Army Transportation Corps, and Naval Air Depots. Also, the Office of Defense Transportation, the U. S. Treasury Department, the Weather Division of the Army Air Forces, the U.S. Weather Bureau and others. The ODT installation is described in Section 2C.

A splendid example of an interconnected system of closely integrated IBM installations was that of the Quartermaster Corps. With a combination of regular IBM punched-card equipment and the IBM card-to-tape and tape-to-card machines, the Office of the Quartermaster General during the war succeeded in reducing the time used on transcontinental telephone lines from fifty to twelve minutes each night for each of their twenty-two depots. Formerly it was possible to maintain a close check on only sixty "controlled" supply items. Mechanization of the transmission not only brought about the reduction in time stated, but also allowed an extension of the existing punched-card stock accounting procedure from 60 to 1, 600 "controlled" items.

The closer control of the additional Quartermaster items made itself felt throughout the national economy. It affected production procurement and transportation, and influenced the supply of goods and commodities available for civilian use. This was also true of the supply situation in the Air Corps, Ordnance Department, Signal Corps, and Naval Air Depots. When the combined bulk and volume of these unprecedented logistical operations is considered, the better control attained with the use of IBM's card-to-tape and tape-to-card equipment immediately resolved itself into figures which represented extraordinary gains.

Wherever the card-to-tape and tape-to-card units were installed, there ensued an extended use of standard IBM punched-card machines in the handling of analyses, reports, summaries, etc. The "telegraphic" availability of data originating at a distance made it possible to utilize the electric accounting machine at the level of management control for purposes that might not otherwise have been feasible.

SECTION 2C

OFFICE OF DEFENSE TRANSPORTATION

Early in 1942, a system of punching a card for every freight car arriving at the ports of New York, Boston, San Francisco, Seattle, Portland, Mobile, Philadelphia, Norfolk, New Orleans, Los Angeles, Charleston, and Baltimore was inaugurated by the ODT. It was from these ports that supplies were sent abroad during World War II.

These steps were taken to secure rigid control over the amount of export traffic which was allowed to flow to each port, based on the number of ships on hand or enroute to the ports. The purpose was to prevent the possibility of cars being used for storehouses over long periods of time, or tremendous quantities of goods being placed on ground storage (as was done on the Jersey flats during World War I) for long periods of time awaiting shipment.

IBM cards were punched by each railroad serving each port. The cards were transported daily to the ODT Traffic Agency at each port for conversion to perforated tapes by IBM 57 machines prior to transmission to Washington. At Washington, duplicate tapes were produced by the telegraph equipment and these were used to punch sets of cards in the IBM 40 machines which were duplicates of cards at the ports.

From these cards tabulated reports were prepared on IBM equipment every twenty-four hours, showing the conditions at each of the ports. These reports provided a basis for determining the quantity of freight that was allowed to move to the seaboard from day to day, or for the transfer of freight from one port to another as circumstances required. They also made it possible to divert trains, even while enroute, to the port which would be able to receive them, unload, and return the cars to service most promptly.

The card information telegraphed to Washington included:

1. The carrier (railroad) code number
2. The date
3. The initial and number of the car
4. The ODT release number under which the car was moving
5. The pier moved from
6. The pier moved to

Additional information was given as to the day the car arrived, whether it was switched to a storage track, whether the contents were placed on ground storage, or the car was placed on a storage track at the port or outside the port, etc.

The number of cards punched and telegraphed to Washington daily approximated 5,900.

The operation was so successful that a moving picture was made dramatizing the procedure.

SECTION 2D

THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD

The subject of mechanization of all car records (freight) and improved yard operations was under study by the New Haven people as early as 1940. The final plan, which was developed jointly by New Haven and IBM personnel in 1942, was not put into actual operation until 1945 because of war-time priorities on equipment. The advantages gained from the plan were as follows:

The mechanization of car records (and their transfer by telegraph) resulted in producing more accurate, more legible, and more complete records in the yard offices and at the Car Service Office, and the improvement in yard office operation resulted in more prompt handling of the cars. The receipt of advanced information by telegraph before the arrival of the train at the next yard provided data necessary for handling the train promptly on arrival through planned switching, use of storage tracks, and icing and other service necessary for perishable commodities. The advance data enabled the work to be organized so that cars could be chalked, side tagged, or carded immediately upon arrival of the train, and allowed more time to check against diversions and reconsignments. By decreasing the time the train was enroute to its destination, through the speeding up of car handling in the yards, the utility of existing equipment was increased. Furthermore, the receipt of complete information at the yards in advance of the arrival of the train made it possible to notify consignees as to a more definite time of delivery of the cars so that arrangements could be made to unload the cars and make them available for service more promptly.

Train departures were also expedited because with the outbound train consist printed automatically by telegraph it was no longer necessary to hold the train until the outbound consist was written.

The receipt of car movement data at one central point (Car Service Office) by telegraph as the moves occurred provided a means for better planning of car distribution and for more prompt dissemination of car movement data to traffic representatives.

The following records were involved:

- Inbound train consists
- Switch lists
- Interchange reports
- Passing reports
- Outbound train consists
- Inbound and outbound yard office records
- Cut-up slips (junction cards)

The plan adopted was based on the use of IBM cards, IBM card-to-tape and tape-to-card machines, IBM sorters and tabulators, and A. T. & T. Teletype tape readers, re-perforators and printers.

The first step in implementing the plan involved the mechanization of the classification yards at Cedar Hill (New Haven) Connecticut, Maybrook (near Newburgh) New York, and the Car Service Office at New Haven, Connecticut.

In essence, the system involved creating a unit record by punching cards containing all necessary interchange and record information for each car received in interchange, for example, at Maybrook, or (for car movements originating in the line) at the first yard equipped with machines, for example, Cedar Hill.

The machines used for punching the cards were Alphabetical Printing Punches and IBM 41 Tape-Controlled Alphabet Printing Punches. These machines printed at the top of the card, simultaneously with the punching, the numerical or alphabetical designation of the hole or holes punched. The printing enabled the data to be easily read by the yard personnel, and the holes provided a means for automatic operation of other devices as described below.

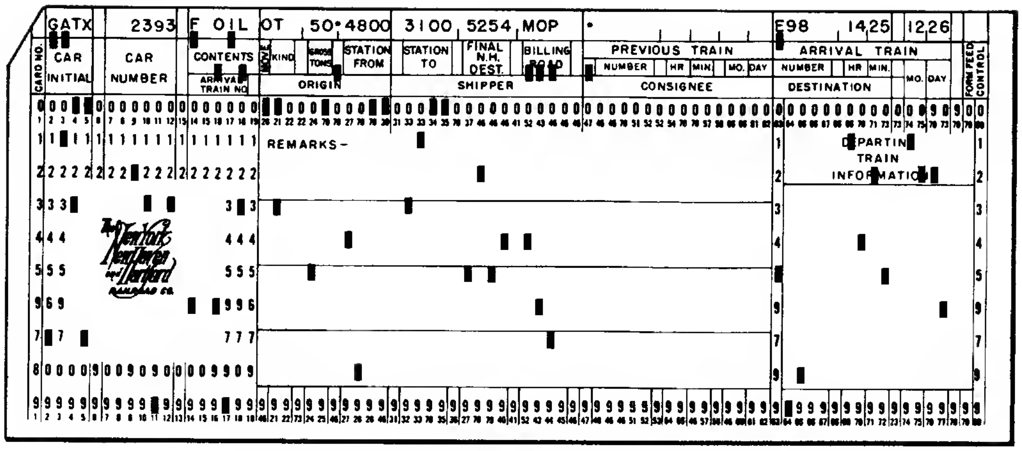
The data registered in the cards corresponded to that written on the waybills or other documents on which the cars were moving and thus the cards became mechanical counterparts of the source documents.

Two cards were punched for loaded cars and one card for empty cars, (see card forms on next page).

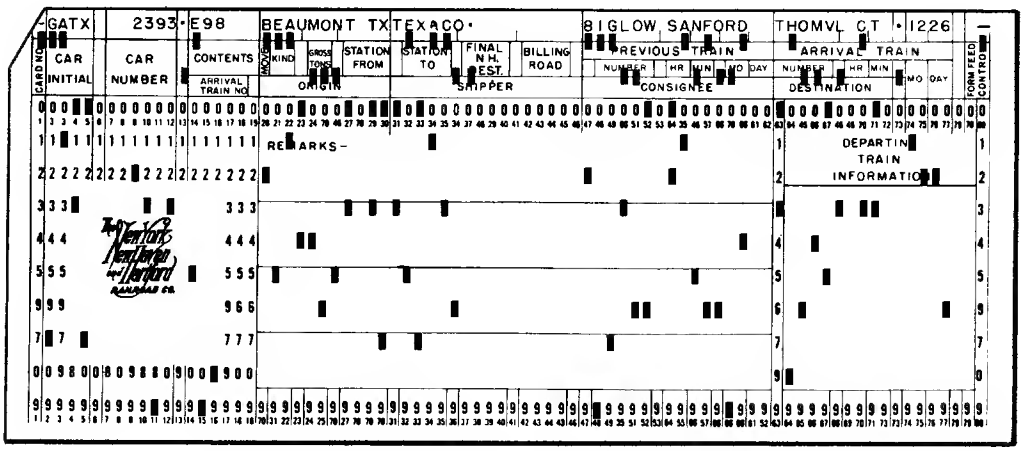
The punched cards were subsequently placed in the card-to-tape machines (IBM 57) to produce telegraphic tapes. The tapes were in turn used to operate printing telegraph machines which automatically typed switch lists, train consists, interchange and other reports, and which were capable of telegraphing the information, as it was typed, to one or more points simultaneously. For example, from the yard office to the towers for switching purposes, from the yard office at Maybrook to the yard office at Cedar Hill and to the Car Service Office, etc.

When the data were telegraphed, a second tape (identical to the original) was produced at the receiving point, or points, and these tapes were then used to produce cards which were duplicates of those used at the yard office which originated the transmission. Thus, it was possible to relay punched-card data from point to point and to produce duplicate files of cards at any desired location with telegraphic speed.

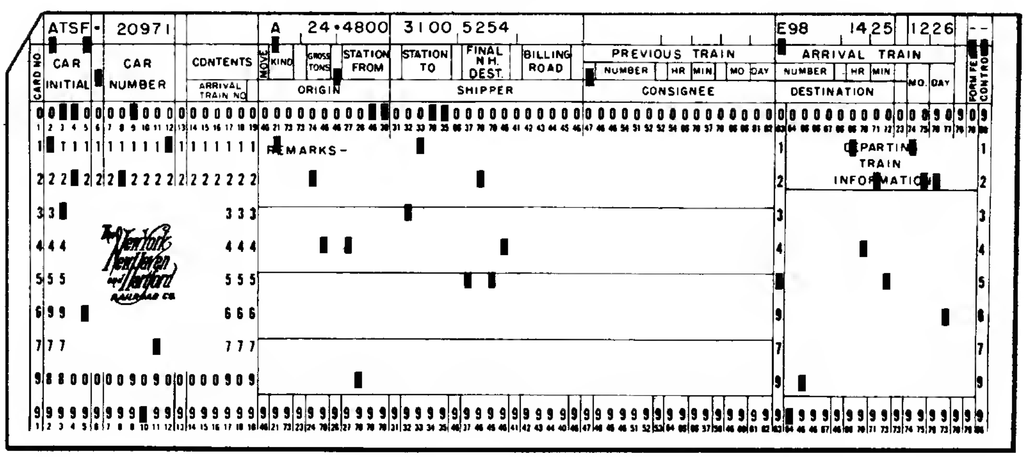
The chart on page 19 shows the operation in an easterly direction from Maybrook to Cedar Hill. The operations for trains moving in a westerly direction between Cedar Hill and Maybrook were basically the same as for the easterly moves except that Cedar Hill was not a point of interchange. In this case, the



First Punched Card for Loaded Car



Second Punched Card for Loaded Car



Punched Card for Empty Car

(Cards Reduced in Size for Purpose of Illustration Only)

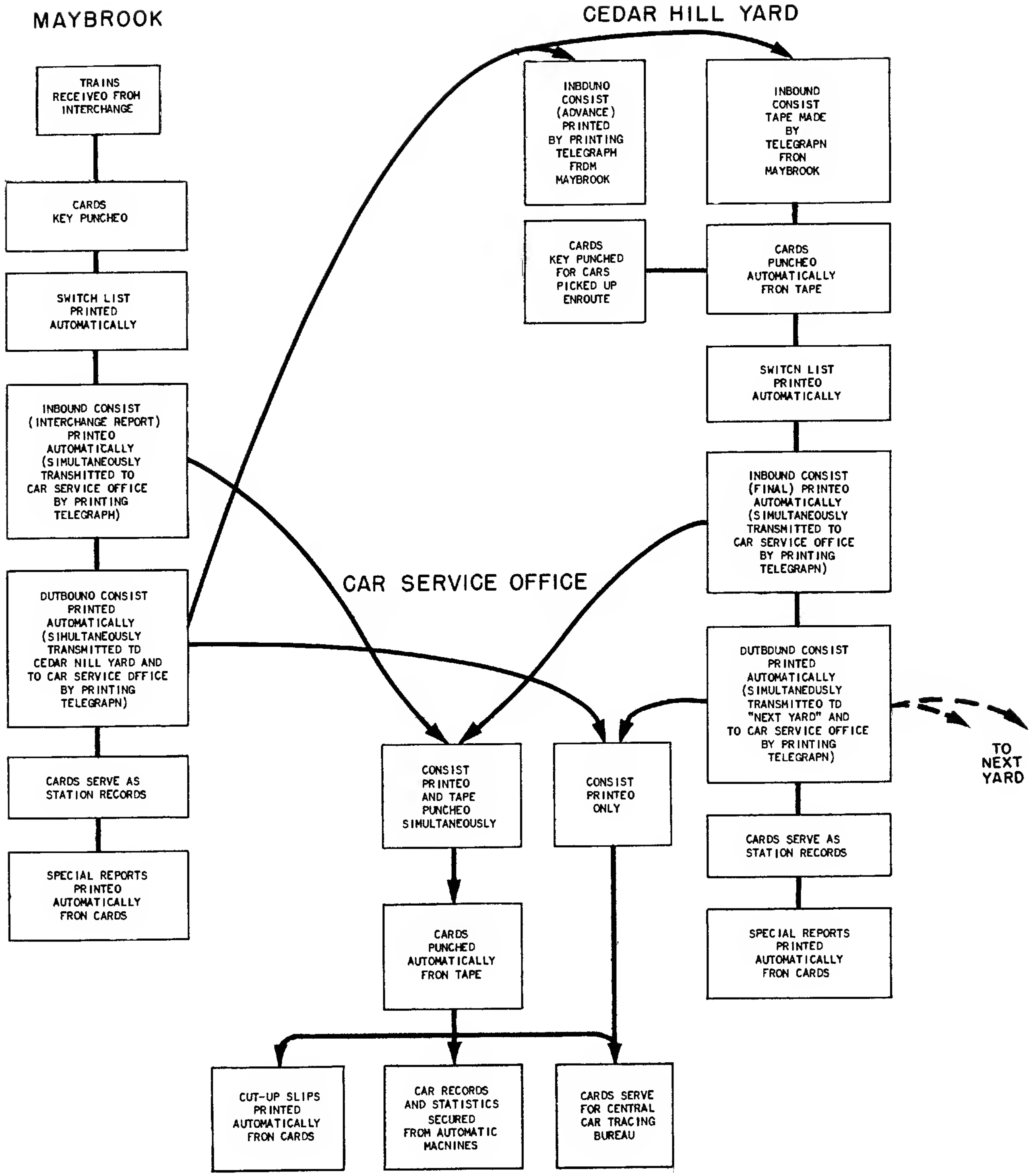


Chart of Operations, Eastbound from Maybrook to Cedar Hill

Maybrook outbound consist served as a report to the railroad to which the cars were transferred, for example, the Erie.

The procedures described were the same for the other yards to which the system was expanded. These other yards are referred to as the "next yard" on the chart of operations.

It will be noted that from one manual recording of the data punched in the cards at the point of interchange (Maybrook), or on the line (Cedar Hill) the typing of all switch lists, train consists, etc., and the punching of all cards at the yard offices and at the Car Service Office was automatic.

From the modest start described, the New Haven subsequently expanded the system to include all 13 of their principal interchange and classification yards. The card volume approximated 100, 000 a day.

Maybrook Yard Office (Interchange and Classification Point)

Cards were punched manually at Maybrook for all cars received in interchange - from the Erie Railroad, for example.

The cards were then used to perforate a paper tape which automatically typed the switch list. This list was transmitted by telegraph to the towermen instructing them how to set the switches for guiding the cars to the various classification tracks as they were humped. The card data recorded in the tape included such information as the car initial and number, contents, type of car, gross weight and destination. Such data as the order of the cars in the train, the track number to which the cars were to be switched, and special instructions were transmitted by operating the transmitting machine keyboard.

The cards were next used to perforate a paper tape which in turn was used to operate printing telegraph machines that automatically typed the interchange report, (see page 21). This report was turned over to the connecting railroad and served as an acknowledgment of receipt of the cars listed therein. Simultaneously with the typing of the interchange report, the data were transmitted by telegraph to the Car Service Office. The cards were then racked with the waybills to correspond to the tracks to which the cars had been switched.

When the outbound trains were ready, the cards and waybills were pulled from the racks. Since the cards can be arranged in any desired order, the same cards which were arranged in inbound train order to control the printing of the switch list and the interchange report were used again to control the printing and transmission of the outbound consist after being rearranged in outbound train order. The cards were then used to perforate a paper tape which was in turn used to operate printing telegraph machines which automatically typed the outbound consist (see page 22). Simultaneously with the typing of the outbound consist a duplicate copy was printed in the Car Service Office, and at the Cedar

PRR -PRR	505620 505620	PAPER	.B 50 BOSTON MASS	3100 3148 NH MASS PAPER CO	.B01 600 416 C R WHITING CO	AKRON OHIO.
PFE -PFE	95818 95818	MDSE	.B 50 BOSTON MASS	3100 3148 NH VARIOUS	.B01 600 416 VARIOUS	OAKLND CAL.

I certify that these cars were received as above,

Agent ______________________ RR.

12345

Use sheets of different colors to distinguish between "Delivered" and "Received" reports

Space for binding and for symbols

Space for binding

DAILY INTERCHANGE REPORT OF CARS

FROM 12:01 A.M. TO 11:59 P.M.

FROM NH TO ERIE AT MAYBROOK 4 16 45 NO 52 ENG 3220 9 00 AM

INITIAL 1.	NUMBER 2.	CONTENTS 3.	KIND / GT / FROM 4. ORIGIN	TO / NH DEST / BILLING RD. 5. SHIPPER	TRAIN NO. / HR. MIN. / MO. DAY 6. CONSIGNEE	DESTINATION 7.
SOU -SOU	12119 12119	MDSE	.B 50 BOSTON MASS	3100 3148 NH VARIOUS	.B01 600 416 VARIOUS	CROXTON NJ.
CRL	8772		R 24	3100 3148	.B01 600 416	
IC -IC	28980 28980	MDSE	.B 50 BOSTON MASS	3100 3156 NH NATIONAL C L	.B01 600 416 NATIONAL C L	SCRANTON .
NYC -NYC	157513 157513	MDSE	.B 70 BOSTON MASS	3100 3148 NH BOSTON BOX CO	.B01 600 416 ACE PACKING	SAN FRAN .
BO -BO	266162 266162	MDSE	.B 60 BOSTON MASS	3100 3148 NH INTL FWDG CO	.B01 600 416 INTL FWDG CO	CHICAGO .

Interchange Report Prepared from Paper Tape

Hill yard office both a duplicate copy of the printed forms and a duplicate tape were produced.

After serving to type the outbound consist, the cards were filed numerically in car number sequence. Because they contained both inbound and outbound train information, they constituted a unified record of the car movement data for all cars handled.

Cedar Hill Yard (Classification Point)

The printed copy of the Cedar Hill "advance" inbound consist (Maybrook outbound consist) was used to organize the work before the arrival of the train.

OB4 12	26 44	LV MAY	BROOK 3 45	PM CONDUCTOR A H	JONES ENG 3265	
GATX GATX	2393 2393	F OIL	OT 50 BEAUMONT TX	3100 5254 MOP TEXACO	.E98 1425 1226 BIGLOW SANFORD	THOMVL CT .
ATSF	20971		A 24	3100 5254	.E98 1425 1226	
BO -BO	255589 255589	STEEL	.G 90 RANKIN PA	3100 8763 PRR PA STEEL	.E98 1425 1226 BETHLEHEM STEEL	FORE RIVER.
RDG -RDG	10274 10274	MDSE	.B 68 CUMB MD	3100 2700 CUMB VARIOUS	.E98 1425 1226 VARIOUS	BOSTON .
INITIAL NYC	NUMBER 74250	CONTENTS	KIND GT FROM F 15	TO NH DEST. BILLING RD. 3100 2200	TRAIN NO. HR. MIN. MO. DAY .E98 1425 1226	
INITIAL CBQ -CBQ	NUMBER 26768 26768	BOTTLS	ORIGIN .B 72 NORFOLK VA	SHIPPER 3100 4348 CO VA GLASS CO	CONSIGNEE .E98 1425 1226 CT GROCERY CO	DESTINATION COLLVL CT .
BO -BO	84141 84141	COAL	-G 82 SCRANTON PA	3100 5200 NYOW BLUE COAL CO	.E98 1425 1226 CONSOLIDATED GAS	HARTFORD C.
ERIE	24700		DD 16	3100 2000	.E98 1425 1226	
GN -GN	42292 42292	FLORNG	.B 65 BUFFALO NY	3100 7900 NYC ACE FLOORING CO	.E98 1425 1226 DELL FLOORING	NEWPORT RI.
MEC	53240		A 24	3100 2200	.E98 1425 1226	
ERIE	13577		A 24	3100 3300	.E98 1425 1226	

Maybrook Outbound Consist

The inbound consist tape (which contained identical information to the printed "advance" inbound consist) was used to punch cards automatically. These cards were duplicates of cards retained at Maybrook with the exception of the "previous train" and "arrival train" data. Cards were key-punched for cars picked up enroute and added to the cards punched automatically from the tape. Cards for cars dropped out enroute (because of hot boxes or mechanical defects) were removed from the pack. The remaining cards were used to print a switch list and the "final" inbound consist. Simultaneously with the typing of the final inbound consist the data were transmitted by telegraph to the Car Service Office. The cards were then racked with the waybills and subsequently pulled and used to perforate the tape for the outbound consist as described for Maybrook, etc.

Car Service Office

At the Car Service Office, a printed listing and a perforated tape were received simultaneously with the printing of the Maybrook interchange report

and the Cedar Hill "final" inbound consist.

The printed lists were turned over to the car tracing desk where they were used for furnishing up-to-the-minute car record and tracing information.

The perforated tapes were used to punch IBM cards which were subsequently put through IBM sorting and accounting machines to prepare car records and statistics and print cut-up slips. The cards were then sorted to car-number order and filed for reference purposes.

The fact that the cards were available by an automatic process (tape-to-card machines) eliminated the manual key-punching from hand-written reports. The receipt of the information by telegraph and the automatic punching of the cards resulting in records being available 3 to 4 days sooner than was possible under the former manual method of operation.

SECTION 2E

MERRILL LYNCH, PIERCE, FENNER & SMITH

Speed and accuracy in executing orders are essentials in a brokerage firm's service to customers. An important factor in such service is the rendering of the bill.

Regulations require that securities sold be delivered to the broker, and that payment for securities bought be received not later than a specified "delivery date" — commonly the third business day following the transaction. Prompt delivery of the exact bill is therefore a convenience to customers as well as instrumental in the prompt settlement of accounts.

Prior to the installation of IBM card-to-tape equipment, the bills (confirmation forms) were printed on IBM 405 accounting machines and mailed to customers at various locations around the country. Where the distances were great the forms were rushed by taxicab or other means to the New York airports and sent by air mail.

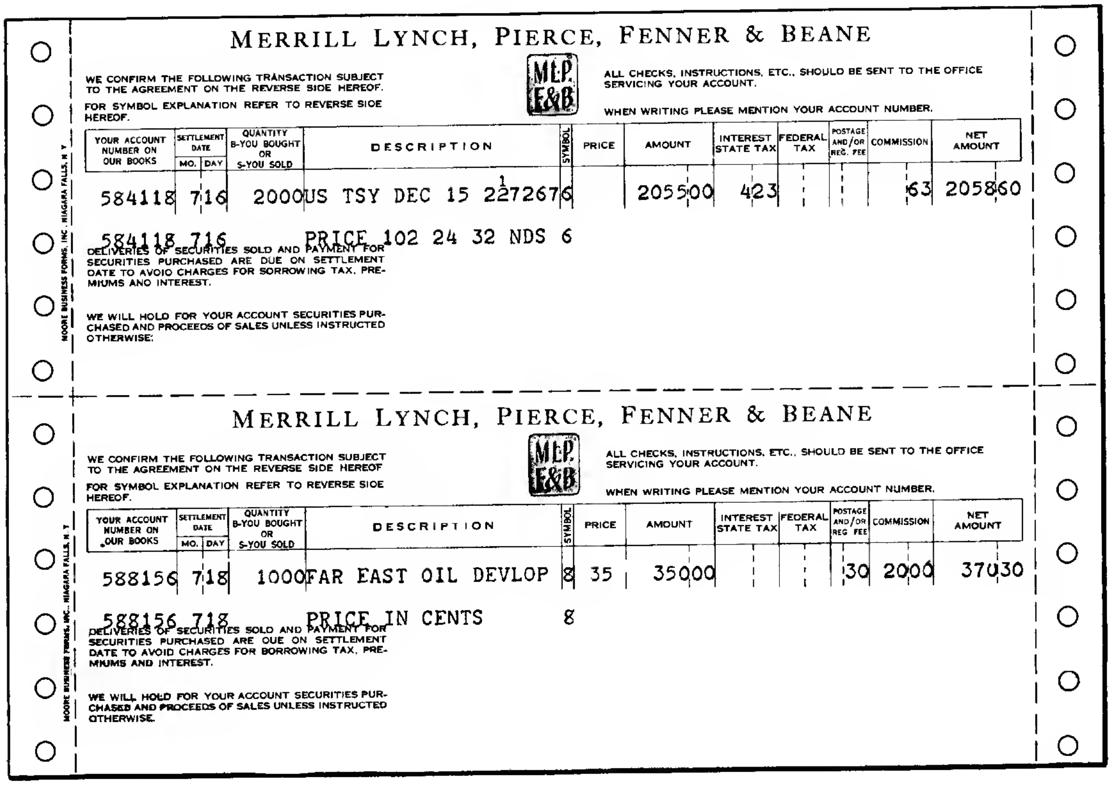
Merrill Lynch had an extensive teletype network in service from New York to approximately 100 offices throughout the United States, some of which were located as far west as California. In 1947 they realized the possibilities of IBM's card-to-tape equipment for automatically cutting telegraphic tapes. These tapes would control their telegraph printers, which would print the confirmation forms daily in the office through which the trade was made. This office was generally at the nearest geographical location to the customer's home or office.

The installation at Merrill Lynch consisted of several IBM 60 card-to-tape machines. Orders for the sale of stocks and bonds were punched into cards throughout the day as they were received by wire from branch offices. At the close of the market these cards were sorted by branch office number and placed in the machines to cut the telegraphic tapes automatically. The tapes were then inserted in a telegraph transmitter-distributor which read the holes punched in the tape and transmitted impulses over the wires to print the forms on standard telegraph printers located in the branch offices (see page 25).

Two copies of each form were printed in the branch offices. The original was addressed and mailed to the customer on the same day that the trade was consummated. The duplicate copy was filed in the branch office under the account number.

The first printing of forms in this manner from New York occurred at the Los Angeles office of Merrill Lynch on the afternoon of September 2, 1947. The

rate of transmission was four forms a minute. At a later date the number of forms printed by telegraph totaled over 7,000 a day at 85 of their branch offices located throughout the country.



MERRILL LYNCH, PIERCE, FENNER & BEANE

WE CONFIRM THE FOLLOWING TRANSACTION SUBJECT TO THE AGREEMENT ON THE REVERSE SIDE HEREOF.

FOR SYMBOL EXPLANATION REFER TO REVERSE SIDE HEREOF.

ALL CHECKS, INSTRUCTIONS, ETC., SHOULD BE SENT TO THE OFFICE SERVICING YOUR ACCOUNT.

WHEN WRITING PLEASE MENTION YOUR ACCOUNT NUMBER.

YOUR ACCOUNT NUMBER ON OUR BOOKS	SETTLEMENT DATE MO. DAY	QUANTITY B-YOU BOUGHT OR S-YOU SOLD	DESCRIPTION	SYMBOL	PRICE	AMOUNT	INTEREST STATE TAX	FEDERAL TAX	POSTAGE AND/OR REG. FEE	COMMISSION	NET AMOUNT
584118	716	2000	US TSY DEC 15 2272676	6		205500	423			63	205860

584118 716 PRICE 102 24 32 NDS 6

DELIVERIES OF SECURITIES SOLD AND PAYMENT FOR SECURITIES PURCHASED ARE DUE ON SETTLEMENT DATE TO AVOID CHARGES FOR BORROWING TAX, PREMIUMS AND INTEREST.

WE WILL HOLD FOR YOUR ACCOUNT SECURITIES PURCHASED AND PROCEEDS OF SALES UNLESS INSTRUCTED OTHERWISE.

MERRILL LYNCH, PIERCE, FENNER & BEANE

WE CONFIRM THE FOLLOWING TRANSACTION SUBJECT TO THE AGREEMENT ON THE REVERSE SIDE HEREOF

FOR SYMBOL EXPLANATION REFER TO REVERSE SIDE HEREOF.

ALL CHECKS, INSTRUCTIONS, ETC., SHOULD BE SENT TO THE OFFICE SERVICING YOUR ACCOUNT.

WHEN WRITING PLEASE MENTION YOUR ACCOUNT NUMBER.

YOUR ACCOUNT NUMBER ON OUR BOOKS	SETTLEMENT DATE MO. DAY	QUANTITY B-YOU BOUGHT OR S-YOU SOLD	DESCRIPTION	SYMBOL	PRICE	AMOUNT	INTEREST STATE TAX	FEDERAL TAX	POSTAGE AND/OR REG. FEE	COMMISSION	NET AMOUNT
588156	718	1000	FAR EAST OIL DEVLOP	8	35	35000			30	2000	37030

588156 718 PRICE IN CENTS 8

DELIVERIES OF SECURITIES SOLD AND PAYMENT FOR SECURITIES PURCHASED ARE DUE ON SETTLEMENT DATE TO AVOID CHARGES FOR BORROWING TAX, PREMIUMS AND INTEREST.

WE WILL HOLD FOR YOUR ACCOUNT SECURITIES PURCHASED AND PROCEEDS OF SALES UNLESS INSTRUCTED OTHERWISE.

Merrill Lynch Forms Printed Automatically in Branch Office

SECTION 2F

VANITY FAIR MILLS, INC.

Vanity Fair Mills was founded in 1899. At the time the card-to-tape installation was made in 1947, the company was one of the leading domestic producers and distributors of women's and "Junior Miss" silk wearing apparel. Its products were marketed under the names "Vanity Fair" and "Extacee." The executive offices and order-invoicing department were located at Reading, Pennsylvania. The principal mills were located at Monroeville and Jackson, Alabama, with smaller mills in New Holland and Denver, Pennsylvania.

Production operations at all mills were controlled by the headquarters office at Reading. On the 15th of each month, a general production schedule was developed as a basis for manufacturing operations of the mills for the next month. The schedule indicated the items and quantity of each item that each mill would produce. Each day the mills forwarded to headquarters a production report which indicated the items being run, the quantity of items completed the previous day, an inventory of items on hand, and shipments made the previous day. The local mills (New Holland and Denver) telephoned these reports to headquarters, while TWX teletype service was used by the Alabama mills.

Customer orders were mailed to Reading where the price, terms and credit rating were verified. The orders were then punched in cards and checked against the production schedule for availability of each item. At that time, ten days usually elapsed between the arrival of an order for items not in stock at Reading and the billing of the customer.

At a conference with Mr. C. T. Winter, Office Manager, at Reading, on November 30, 1943, he stated that he had seen the IBM card-to-tape machines in operation at the Middletown, Pennsylvania Air Corps depot and that he was impressed with the possibilities they offered for his business. He explained that their business had become highly competitive and that he looked for even keener competition after the war. Therefore, he was interested in speeding up deliveries to customers.

As a first step in this direction, Mr. Winter stated that they would like to use the cards now punched from the incoming orders to prepare telegraphic tapes which would operate two Teletypewriters simultaneously, one at Reading and the other at Monroeville, in such a manner that the machines at Reading and Monroeville would print several copies of the information on identical continuous forms. The original form printed at Monroeville was to be the invoice. The remaining copies were to be used for scheduling, accounting, and production. The forms to be printed on the Reading Teletype were mainly for accounting purposes. Orders would continue to be filled from Reading stock

where possible and the invoices would be printed on the IBM accounting machine.

The proposed system would alter the present tabulating procedure to the extent that all of the invoices now printed on the accounting machine, covering shipments made from Monroeville, would be printed on the Teletypewriter. In a majority of cases, the proposed system would enable Vanity Fair to ship and bill the same day the orders were received at Reading.

We were still at war in 1943 when the new system was proposed, and machines and telegraph circuits were at a premium. It was not until the middle of 1947 that the plan was put into effect, using the IBM 60 card-to-tape units.

Orders which could not be filled at Reading were sent by telegraph to the Monroeville mill using IBM card-to-tape machines to produce the transmittal tapes. In order to produce the heading of the form (see page 28) it was necessary to pull a set of heading cards for each customer involved and associate them with the manually punched detail cards. The cards were then put into the machine to cut the tape automatically. The tapes were run each working day to print the forms. An average of 175 invoices were transmitted each day.

The following benefits were derived from the plan:

1. Faster deliveries — The receipt of orders 3 days earlier than was possible under the old method, allowed the mill to ship the orders 3 days sooner.

2. The elimination of peak loads at the mill created daily by two mail deliveries. Normal operations in several units were interrupted immediately after each mail delivery as the new orders were received, sorted and distributed. The telegraphic system permitted the orders to be received in an even flow throughout the day. This facilitated orderly assimilation in the regular daily work load without impairment to the normal routine.

3. A reduction in the inventory period for which goods were held at the mill pending the receipt of orders was reduced from 4-1/2 to 1 day. This was reflected in a financial saving, as goods held in inventory represented capital which was not earning money for the concern.

4. An additional financial gain was made by the earlier receipt of three days' collections together with the interest these funds earned.

5. A reduction in the cost of mailing and handling the order forms between Reading to Monroeville.

OKKEEPING 4

A Division of Vanity Fair Mills, Inc.,

Extacee INC.

Reading, Pennsylvania

Showrooms
10 East 40th Street
New York 16, N. Y.

SOLD TO
MARSHALL FIELD
AND CO INC
121 N STATE ST
CHICAGO 54 ILL

SHIP TO
MARSHALL FIELD
AND CO INC
OAK PARK ILL

BILLS NOT PAID AT MATURITY SUBJECT TO SIGHT DRAFT WITHOUT NOTICE.

NO ANTICIPATION ALLOWED
NO DEVIATION FROM TERMS

ACCOUNT NUMBER	TERMS	SLM.	DEPARTMENT
U53044	1 10 EOM	80	408

CUST NO 41439
ORDER NUMBER

DATE: 90447

INVOICE NUMBER: 00002

STYLE	COLOR			9	11	13	15	DZS.	PRICE	AMOUNT
120953	BBL GARD	40		4	2	4	2	10	6300	6300
120953	GARDENIA	40		2	4	4	2	10	6300	6300
120901	CAM BBL	40		3	3	3	3	10	2800	2800
120901	CARD POP	40			3	3	3	9	2800	2100
120805	GARDENIA	40		1	2		1	40	1750	7000
120301	GARDENIA	40		1	2	2	1	60	875	5250
120301	CAMELLIA	40		6	6	6	6	20	875	1750
								159		31500

CONTROL NUMBER

A 29

THIS IS NOT AN INVOICE NO.— INVOICE NO. APPEARS ABOVE SIZE SCALE

PATENTED—MOORE BUSINESS FORMS, INC., NIAGARA FALLS, N. Y.

1003

Sample of Invoice Printed from Tapes which Enabled Mill to Bill and Ship Same Day Order Was Received

SECTION 2G

PATENTS

The basic patents on card-to-tape and tape-to-card machines, involving five channel paper tape operation, were granted to the writer in 1944. Patents 2, 340, 800 and 2, 340, 801 were both dated February 1. A total of 83 claims were allowed.

In addition to the two basic patents referred to above, the following patents were issued to the writer:

Number	Subject	Date	Number of Claims
2, 343, 405	Unshift on Space	3/7/44	1
2, 377, 766	Card-to-Tape Expansion	6/5/45	22
2, 357, 460	Card-to-Tape Condensation	9/5/44	9
2, 372, 887	Automatic and Manual Card-to-Tape	3/3/45	10
2, 391, 773	Zero Suppression	12/25/45	15
2, 399, 725	Zero to the Left	5/7/46	9
2, 573, 317	Consecutive Blank Columns	10/30/51	5
2, 475, 315	Card-Tape Verifier	7/5/49	14
2, 637, 399	Type 43 Tape-to-Card Machine	5/5/53	21

SECTION 3A

CARD-TO-CARD TRANSMISSION (THE DATA TRANSCEIVER)

This second step in providing TELE-PROCESSING equipment was to improve the card-to-tape and paper tape-to-card transmission system in three important respects:

1. To eliminate intermediate steps

2. To improve the transmission accuracy

3. To increase the speed of transmission

The machine which was developed to meet these objectives is known as the Data Transceiver.

With reference to Item 1, the Transceiver provides direct card-to-card transmission, thus eliminating the conversion steps from card-to-tape and tape-to-card which are necessary with the machines described in Section 2.

With reference to Item 2, two considerations are involved: one is the matter of the transmission code; the other the design philosophy of the equipment.

The Baudot code, which is used in card-to-tape and tape-to-card transmission, contains five elements as shown in Appendix A. All of the possible combinations of code elements are used and consequently a device controlled by this code will record any information it receives without discrimination. For example, telegraph machines will print (or punch in tape) a 1, a 2, a 6, or a 9 for a 5 in cases where noise on lines or static on radio circuits adds one or more elements to the transmitted character code.

For message transmission,character mutilations are of minor importance (except where figures are involved) because it is rare for text to be sufficiently garbled to destroy its meaning. For the transfer of accounting, financial and engineering data, however, a higher degree of accuracy under all transmission conditions was considered necessary. For this reason the transmission code element arrangement which was selected for the Transceiver is of a checkable nature (Appendix E). In this code each numeral, alphabetical or special character is composed of four code elements out of a possible total of eight. For checking the accuracy of transmission of this code,a device was included to count the number of code elements received. If the total is anything other than four, the machine automatically rejects the character before it is recorded in the card and stops the receiving and transmitting machines. Transmission

errors for this code are only possible if, within the same character, one or more code elements are omitted and a corresponding number of elements added to produce a legitimate code and to satisfy the counting device. Tests over wire line and trans-oceanic radio circuits and in many Government and commercial applications since the machines were first produced in 1954 prove that the degree of accuracy provided by this type of code is extremely high.

The design philosophy of the Transceiver is such that the receiving machine "supervises" the operation of the machine transmitting and the connecting circuit. This is accomplished by the receiving machine operator pressing a button on the control board which lights a signal on the transmitting machine and conditions it so that depression of its START key will cause the first card to be transmitted. As long as the receiving machine is satisfied with the composition of every character received for each card, that the correct number of card columns have been punched, that there were cards in the machine to be punched, plus many other checks, the transmission and reception will proceed uninterrupted. This high degree of supervision is accomplished by sending a signal from the transmitter, following the transmission of each card, which in effect asks the receiving machine if it is satisfied with the card it has just received. If it is, a "go ahead" signal is sent back to the transmitter which permits it to send the next card. If the receiver is not satisfied with the card and does not send the "go ahead" signal, the transmitter will lock up so that the card under transmission can be repeated. This high degree of interconnection means that as fast as the cards are produced by the receiver they can be put into the work stream with confidence that the information has been transmitted accurately.

In order to provide for faster transmission, Item 3, the Transceivers were designed to operate on private wire telephone channels at a speed of 11 fully punched 80-column cards per minute (approximately 16 characters per second).

As an illustration of the improvement in overall speed provided by the Transceivers, the Air Force conducted a spot test between Mitchel Field and the Pentagon in which a group of 200 cards was transmitted by the card-paper tape method and the same group was transmitted by Transceivers. The card-paper tape transmission by telegraph required 3 hours and 42 minutes to produce an accurate result. On the same basis the transmission by Transceivers, over telephone facilities, required 18 minutes.

As many as four pairs of Transceivers can be operated over the same telephone channel at one time, producing 44 fully punched cards per minute. This type of installation is used only where the volume of cards and urgency of receipt of the information justifies the cost of the additional equipment.

In order to provide for operation over telegraph circuits and short wave radio circuits where a high degree of accuracy is desired and where the volume of traffic is comparatively small, a second model of the Transceiver was arranged

to operate at slower rates of speed. When operated over such facilities, the speed is approximately 3 fully punched 80-column cards per minute for 60-word circuits, 4 cards for the 75-word circuits and 5 cards for the 100-word circuits.

As it was expected that in most instances these machines would be used as alternates to telephone or telegraph facilities, buttons and signal lights were provided so that if questions arose during transmission, the operators could signal for oral or printed communication on the alternate facility.

A complete description of the Data Transceiver will be found in Appendix E.

A solid state model of the Transceiver was built in 1955. A new approach to packaging was used which eliminated the auxiliary signal unit cabinet used with the tube machines. Estimates indicated a small saving in cost. Some difficulty was experienced in operating relays reliably with the transistors available at that time. Following completion of the model and preliminary tests the project was abandoned.

The last outside patent involved in direct card-to-card transmission expired in 1955 shortly after the first machines were produced. Section 3B lists the patents involved in direct card-to-card transmission and includes a brief description of each.

In addition to the speed option, two models of the punch unit were provided. One used the IBM 24 non-printing card punch and the other the IBM 26 printing card punch. These two units and the two signal units required for the speed options were assigned the following type numbers:

65 non-printing punch
66 printing punch
67 telegraph signal unit
68 telephone signal unit

Up to September 1, 1960, a total of 2, 294 machines had been shipped from the Poughkeepsie Plant. The first IBM 66 unit was shipped in December, 1954 and the first IBM 65 was shipped in January, 1955.

A breakdown of the machines shipped is given below:

Transceiver Shipments

	IBM 65	IBM 66
New & Rebuilt	377	1741
Reconditioned	84	92
Total	461	1833

As of April 1, 1960, there were 213 IBM 65 and 1178 IBM 66 machines installed. This represents an annual rental of approximately $3, 200, 000. The machines are currently in production at Poughkeepsie.

Section 3E describes a hookup between General Electric and IBM facilities in which cards were transmitted over a voice telephone channel from Evendale, Ohio to the IBM Technical Computing Bureau at 590 Madison Avenue, New York, N. Y. The cards were processed in an IBM 701 computer and the answers were returned over the same transmission facility.

The first scheduled overseas radio transmission of punched cards was inaugurated in March, 1955 (Section 3F) by the Army Signal Corps. The Transceivers operated over land lines and trans-Atlantic short wave radio between Tobyhanna, Pennsylvania and Orleans, France. The principal reason for the hookup was to speed up requisitioning of supplies required by the Army in Europe.

Following the Signal Corps Transceiver hookup between Orleans, France and Tobyhanna, Pennsylvania, many additional Transceiver radio and some cable circuits have been established between points in the U. S. and overseas locations. For example, at this writing the Air Force has established Transceiver radio circuits for the transmission of punched cards between the following points:

California	and	Alaska
"	"	Hawaii
"	"	Okinawa
"	"	Formosa
"	"	Phillipines
"	"	Korea
"	"	Japan
Washington	"	Newfoundland
"	"	England
"	"	France
"	"	Germany
"	"	North Africa
"	"	Puerto Rico
"	"	Canal Zone

In addition, cards are being transmitted by Transceivers by the Air Force between Washington and England and between California and Hawaii via submarine cable.

A circuit is in operation between Washington and England over one channel of the telephone cable. This circuit permits the transmission of cards simultaneously on four channels using eight Transceivers, four in Washington and four in England. The machines are occasionally operated up to 24 hours a

day. The number of cards transmitted daily approximates 30,000 to 40,000.

A high speed (10 - 11 cards per minute) radio circuit is in operation between Hawaii and Japan.

Approximately 300 Air Force installations, at home and abroad, are interconnected by means of Data Transceivers. A large majority of all Air Force requisitions are now handled by Transceivers.

Section 3G describes a trans-Atlantic radio hookup in which replacement personnel can be requisitioned from Europe. It is stated that the system resulted in a saving of $10,000,000 a year.

The large Transceiver hookup installed by the Chicago & North Western Railroad is described in Section 3H. It is the largest commercial Transceiver installation in the world.

On March 16, 1960, a modification of the telephone signal unit enabling the machines to be used on regular dial-up (message toll) telephone circuits was announced. The first commercial installation was at Firestone Tire & Rubber Company as described in Section 3I. A total of 69 machines have been equipped for this type of service through July 1, 1960.

SECTION 3B

PATENTS

Looking ahead to the time when higher speeds would be required and when cards could be transmitted directly without the intermediate paper tape step, the writer had several conversations with CHQ Patent Department. These conversations were held in 1945 and early in 1946.

The patents then in force which had a bearing on direct card-to-card transmission were the following:

1. Reading a card, changing from the tabulating to a telegraphic code, and transmitting the data (by wire or radio) using the start-stop method of transmission was covered by Nelson patent 2, 129, 743 owned by Associated Electric Laboratories, Inc. and which expired in 1955.

2. Assuming that we purchased or acquired a license under the Nelson patent, we would then have been in a position to read a card, column by column, change the tabulating code to a telegraphic code and transmit by means of an electromechanical start-stop system. We would not have been able to use an electronic commutation system, because of the Potts Reissue patent 21, 778. This patent was owned by A. T. & T. and expired in 1946.

3. Assuming both the above patents were cleared, we were still limited to reading the cards column by column and transmitting in the same sequence as the data were punched in the cards. Also we were prohibited from printing during receiving, because of Bailey patent 2, 034, 791, owned by A. T. & T., expiring in 1953. The ability to transpose card fields during the transmission process did not appear as a serious limitation. More serious was the restriction on printing at the receiving end simultaneously with the punching. This prohibited the use of printing punches directly connected to a transmission circuit. The importance of printing is borne out by the fact that of the total of 1391 Transceivers which were in the field on April 1, 1960, 1178 were equipped with printing devices.

The patent on the IBM Transceiver has not yet been issued.

SECTION 3C

THE DATA TRANSCEIVER

(ENGINEERING MODELS AND TESTS)

An appropriation for the development of the machines was authorized late in 1951. Construction of experimental circuitry and machines was begun in early 1952. By the end of 1952, "breadboard" machines were operating satisfactorily over telephone lines from Poughkeepsie to New York City and return. Construction of two machines suitable for field testing was begun in late 1952 and completed in March 1953. One of these machines was a transmitter and the other a receiver. A seven-element, odd parity-checked code was used for transmission.

These machines were tested by the American Telephone and Telegraph Company in July 1953. The tests included operation over open wire, carrier, underground and submerged cable, and microwave telephone circuits. Operation was tested on four channels, with carrier frequencies of 800, 1300, 1800 and 2300 cycles per second.

The susceptibility of the machines to echo interference was measured on a 1000 mile telephone circuit. As a result of these tests, the A. T. & T. engineers concluded that the machines were satisfactory for operation on leased telephone circuits.

The Office of Statistical Services of the Air Force became interested in using machines of this type to handle the large volume of punched-card reports transmitted by teletype between various bases and the Pentagon. A thirty-day field test of the machines was conducted during July 1953 in cooperation with the Air Force. Cards were transmitted over a 300 mile telephone circuit from Mitchel Field, Long Island, to the Pentagon. Approximately 5,000,000 card columns were transmitted.

Following this field test, both the transmitting and receiving functions were incorporated into a single machine, and the first two Transceivers were built.

All four of these model machines (the transmitter, the receiver and the two Transceivers) were field tested for thirty days in November and December 1953. This field test was conducted over the same telephone facilities as before between Mitchel Field and the Pentagon. During this period, the Military Affiliate Radio Service of the Air Force set up a radiotelegraph circuit, and the Transceivers were operated over this circuit for part of the test. The radio test was too short to provide conclusive evidence, but the results did indicate that the machines were adaptable to radiotelegraph operation. Approxi-

mately 10,000,000 card columns were transmitted during these tests.

After this field test, the first two Transceiver models were installed in Hartford, Connecticut for use by the United Aircraft Corporation. The machines were placed in service in February 1954.

Two new Transceivers were built to replace the ones sent to Hartford, and both telephone and telegraph signal units were built for use with these machines. Both field tests had demonstrated that the single check bit redundancy type of code in itself was not accurate enough and further work on transmission codes resulted in the development of a fixed-count, four-out-of-eight code.

Telegraph operation was first tested in cooperation with the Western Union Company. Both 75 and 100-speed operation (using polar signaling) were used on 150, 2000, and 6000 mile telegraph circuits. During these tests measurements were made to determine the effects of telegraph signal distortion. Western Union engineers concluded that the machines would not require any extraordinary maintenance of telegraph line equipment and that they were in fact less susceptible to signal distortion than standard telegraph printers.

The Air Force requested another field test to provide further evaluation of machine performance on long distance radiotelegraph circuits. One field test was conducted during June and July 1954, between Pepperrell Air Force Base, Newfoundland, and Andrews Field (near Washington, D.C.) and another between the Naval Communication Center at Port Lyautey (French Morocco) and Washington, D.C. The machines were operated for about a week on each circuit. Approximately 800,000 card columns were transmitted at telegraph speed (3 cards per minute) with one error, and another 800,000 card columns were transmitted at telephone speed (11 cards per minute) on the Morocco-Washington circuit with four errors.

An analysis of the five errors revealed that three could be eliminated by circuitry to detect loss of receiver synchronization. This change was included in all production machines. The remaining two errors were attributable to the variable characteristics of long distance radio transmission at the 11 card per minute speed.

These radio field tests received considerable publicity, and representatives of all interested departments of the Army, Navy, and Air Force saw the machines in operation and received a summary of the results of all the field tests.

In September 1954, telegraph operation was tested by the American Telephone and Telegraph Company. The machines were tested at 60, 75, and 100 word speeds over several telegraph lines ranging up to 4000 miles in length and using up to ten carrier telegraph sections. Satisfactory operation was obtained on circuits which would require two and perhaps three regenerative repeaters for telegraph service.

During July and August 1954, the physical layout of the electronic signal units (IBM 67 and 68) was revised and the prototype construction of 14 of these units was subcontracted to Daystrom, Inc. of Poughkeepsie. The first IBM 66 was shipped from Poughkeepsie in December of 1954. The first IBM 65 was shipped in January, 1955.

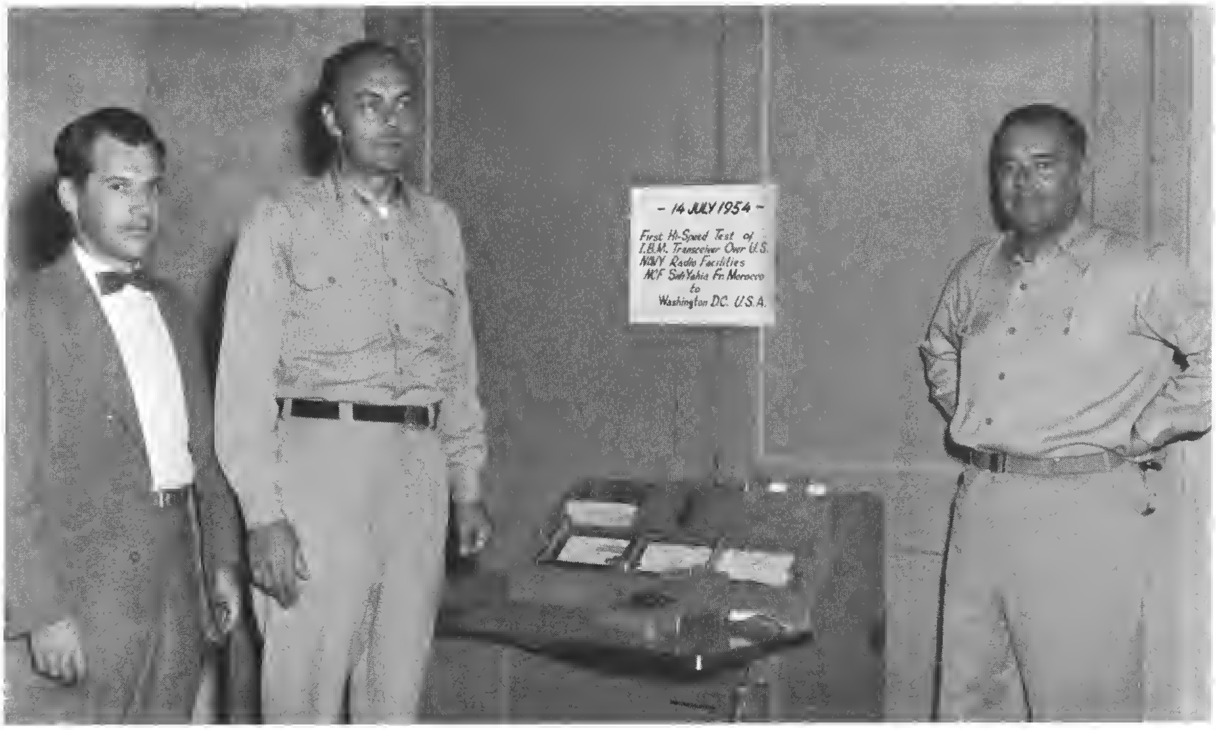
SECTION 3D

TRANSMISSION MILESTONES

Below is a listing of the important tests which were made of the Transceiver models on telephone, telegraph and radio circuits. Also included are the first trans-Atlantic and trans-Pacific transmissions in regular service, and the tests which were conducted by A. T. & T. at New York which resulted in their approval of Transceivers for use on telephone and telegraph channels. Where "and return" applies, both the machine transmitting and the machine receiving were located at the same city and the circuits were looped to the remote point and return.

From and To	Transmission Medium	Speed in Cards/Min.	Date
Poughkeepsie, N. Y. to New York City and return	Telephone line	12	Feb. 1952
*New York, N. Y. to Roanoke, Va. and return	" "	11	July 1953
Mitchel Field, L.I. to Washington, D.C.	" "	11	July 1953
" " "	" "	11	Nov. 1953
" " "	Radio	5	Nov. 1953
Poughkeepsie, N. Y. to New York City and return	Telegraph line	4	Feb. 1954
Poughkeepsie, N. Y. to Chicago and return	" "	4	Feb. 1954
Poughkeepsie, N. Y. to Oakland, Calif. and return	" "	4	March, 1954
Newfoundland to Washington, D. C.	Radio	3	June, 1954
Port Lyautey, No. Africa to Washington, D. C.	"	4	July, 1954
" " "	"	11	July, 1954
**New York to various cities and return	"	3-4-5	Sept. 1954
***Orleans, France to Tobyhanna, Penn.	"	3	March, 1955
***Tokyo, Japan to Oakland, Calif.	"	3	Feb. 1956

(*A. T. & T. telephone acceptance tests)
(**A. T. & T. telegraph acceptance tests)
(***Actual installations)



First Trans-Atlantic Test of IBM Transceiver was made from French Morocco to Washington, D. C. via Radio in July 1954. At Sending Point, Port Lyautey, were (L to R) Roy Smith, IBM Engineer; Major Marecki, USAF; and Captain Tuthill, USN.

Business Machines reported on the Port Lyautey-Washington, D. C. radio transmission under the caption "TRANSATLANTIC RECORD SET." The complete write-up follows:

"On a summer morning seventeen years ago last month, a shy, sixty-three-year-old Italian died in Rome. If Marchese Guglielmo Marconi, father of modern radio, had lived, he would have been astounded at some of the uses to which his brain child has been put, particularly one demonstrated on July 12, 1954.

"On that day, a punched card machine operator in Port Lyautey near Casablanca, Morocco, put some punched cards into a machine. A moment later, exactly at 1:53 p.m., he flipped the machine's switch. At the same instant, three thousand miles away in Washington, D. C. — where because of the time differential it was 9:53 a.m. — duplicate cards began to move swiftly out of a similar machine.

"Magic ?

"No. This feat was accomplished by a set of IBM Data Transceivers linked

across the Atlantic by radio in a U.S. Air Force project. It was the first data to be radioed across the ocean directly from one punched card to another.

"The Air Force's experimental card-to-card transmission between Morocco and Washington continued for a week and was observed by Army and Navy officials. During this time, the Air Force sent and received statistical information at the speed of approximately 1,000 characters a minute. With the cooperation of the U.S. Navy, which made its radio circuits available, the transmission was made between the Naval Communication Facility, Port Lyautey, and the Naval Communication Station, Washington.

"These Data Transceivers, recently developed by IBM can'talk' to each other over radio, telephone or telegraph circuits, although commercial models are available for use only over telephone and telegraph.

"Here's how they operated in the Air Force test: The Data Transceiver at Port Lyautey read the cards and generated electronic impulses — inaudible to the operator but audible to the equipment. Each series of impulses represented a hole in a card. These signals were sent by radio across the ocean. They actuated the punching mechanism of the Data Transceiver in Washington, which simultaneously created duplicates of the cards in Morocco. The machines automatically checked their own accuracy by inspecting each card before the next one was transmitted.

"Air Force officials, who plan to use Data Transceivers to send and receive statistical data from bases, say this method is faster, more accurate and more economical than any previous system of transmitting detailed accounting and logistical data.

"The up-to-the-minute reports on men and equipment supplied by the units will eliminate a number of steps in accounting procedures dealing with the deployment of military forces and the distribution of replacement equipment now maintained at bases. As Air Force officials explain it, with the extremely accurate Data Transceivers speeding the processing of the data, replacement parts for fighters and bombers at overseas bases could be requisitioned quickly from a depot in the U.S.

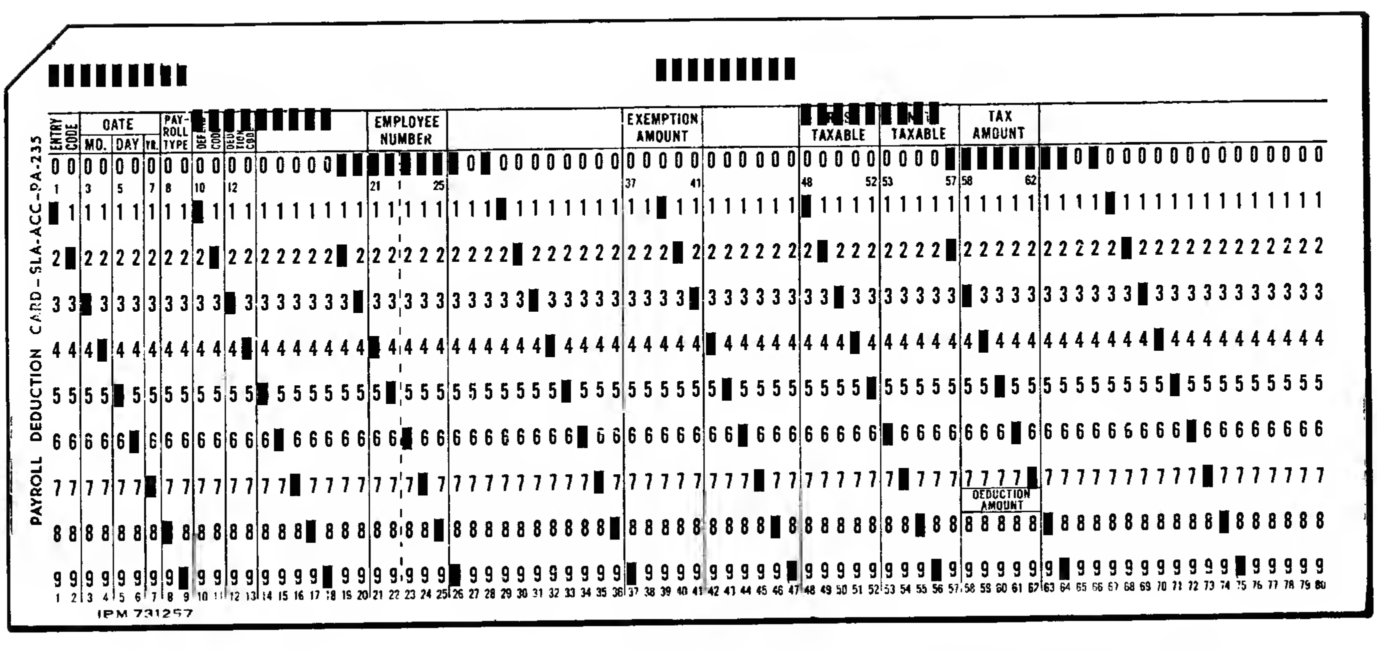
"Interviewed in his Pentagon office, Major General Charles R. Landon, Director of Statistical Services, Headquarters, U.S. Air Force, described this new use of the machines as 'one of the most significant steps the Air Force has taken in the utilization of punched card equipment.'

"The Air Force's trans-oceanic experiments followed similar tests conducted in June between Andrews Air Force Base, Md., and Pepperrell Air Force Base, near St. John's, Newfoundland. The experiments were observed by representatives of the Army and Navy. Army officials state that they are considering the utilization of the machines for transmission of supply data.

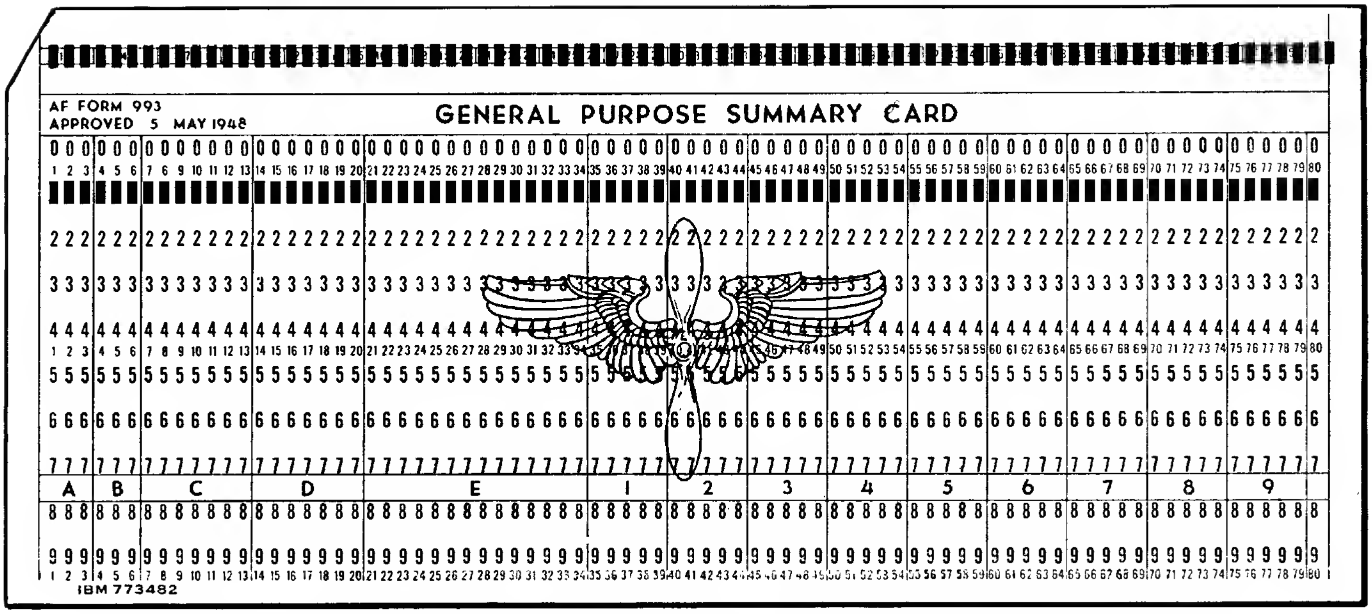
"Pepperrell is only a few miles from the spot where Marconi, on a cold December day in 1901, received a series of radio signals from Cornwall, England. That was the world's first trans-oceanic wireless message.

"Though the Air Force demonstrated a use of radio never anticipated by Marconi, still to him the future of radio was unlimited. The Italian inventor even predicted radio communication with beings on other planets.

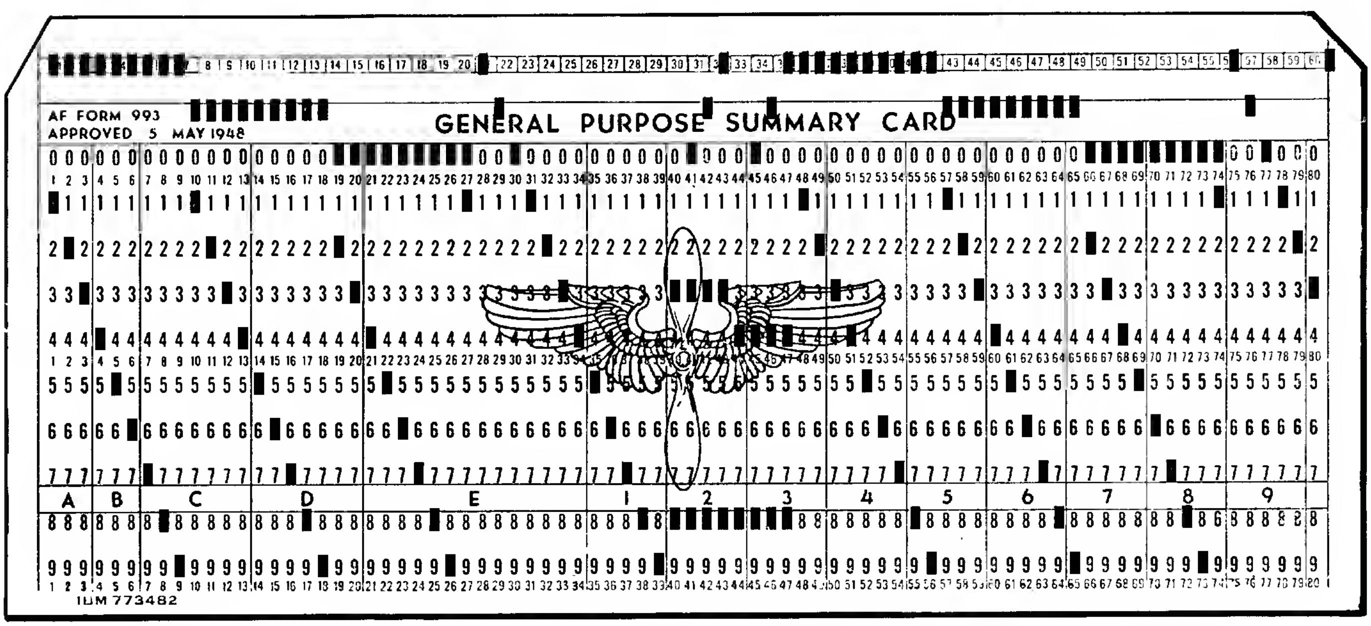
"With the great strides achieved in the progress of communications during the mere seventeen years since Marconi's death, who can say now that his prophecy will be false?"



Replica of One of First Cards Reproduced Over a Telephone Channel by Transceiver — Poughkeepsie to New York and Return. February 26, 1952.



Replica of First Card Reproduced Over Short Wave Radio by Transceiver – Newfoundland to Washington, D. C. June 18, 1954.



Replica of First Card Reproduced Across Atlantic Ocean by Transceiver – Port Lyautey, French Morocco, North Africa to Washington, D.C. via Navy Short Wave Radio. July 12, 1954.

will be possible. The station at IBM World Headquarters will be discontinued in 1955 when GE receives additional IBM electronic data processing machines.

"'This system provides an exciting foretaste of what can be expected in the field of data processing between remote points,' according to Dr. H. R. J. Grosch, Manager of Investigations, Aircraft Gas Turbine Development Department, which operates the machine at Evendale.

" 'Although we are concerned principally in this setup with processing of design and engineering problems,' said Dr. Grosch, 'it takes little imagination to envision a similar network tying in many plants and branch offices for the central handling of standard accounting and record-keeping procedures. IBM has shown commendable vision in being alert to the communications requirements of such a system as well as in the mass production of the necessary computers and data processing machines.'

"Opening of the network today was witnessed in New York by a number of GE officials including Glenn B. Warren, Vice President and General Manager of the turbine division, and Allen Keller, Supervisor of Turbine Development Engineering at GE's Lynn Laboratory. IBM representatives included Thomas J. Watson, Jr., President, and T. V. Learson, Vice President.

"The problems being processed by this system are concerned with the highly technical engineering calculations required for development of jet aircraft power plants and steam turbines. Problems formerly requiring weeks or months by manual methods now require only minutes on the high speed computers.

"For example, the thrusts and fuel consumptions of development jet engines must be calculated at many different speeds at each altitude. It is literally impossible to do the calculations manually, GE engineers explain. There are millions of calculating steps for each set of conditions. Each step depends on the accuracy of all preceding operations and anyone attempting this manually probably would make a mistake.

"Value of the new hookup and the computing facilities it links is further illustrated by a typical industrial situation in which a power company asks GE to provide specifications for a turbine to meet special requirements. The prospective customer needs additional power plant capacity to take care of his steam and electrical loads.

"Under former hand methods, it might require three or four weeks to come up with an elementary design for the turbine. Now, assuming that the request was made of the GE medium steam turbine, generator and gear department at Lynn engineers there would put the necessary data on the teletype to Evendale or New York, using a pre-established program. The new data would be dropped into the 701 and the analytical section of the job can be completed in twenty-four hours.

"The communications systems allow various engineering groups throughout GE to have available these new engineering tools to speed the solution of their problems. This also provides a facility which one group alone might not be able to justify financially. The modern high speed automatic computer is serving to advance the art of engineering by allowing much more to be done in the areas of theoretical investigations, thus reducing the amount of cut and try effort, and appreciably shortening the elapsed time between the accepting of an idea and the marketing of a product."

Glenn B. Warren, vice president and general manager, Turbine Division, General Electric, Schenectady, receives from Mrs. Betty Horn, a deck of punched cards containing data on a steam turbine design problem, at opening of G. E. four-point data transmission circuit. Looking on at IBM's Technical Computing Bureau in New York, are Thomas J. Watson, Jr., IBM president, and Allen Keller, supervisor of turbine advance and development engineering of G. E.'s Medium Steam Turbine, Generator and Gear Department, Lynn, Mass.

SECTION 3F

SIGNAL CORPS OVERSEAS TRANSMISSION

The first regular overseas radio transmission of punched cards was inaugurated by the Army Signal Corps between Orleans, France and Tobyhanna, Pa., in March 1955 on a trial basis. The purpose of the installation was to establish a radio communication link between Europe and the Signal Corps branch depot at Tobyhanna in order to expedite the shipment of supplies. Cards were punched at Orleans for supply items required in Europe and transmitted from Orleans to Tobyhanna via the following hookup: Land line from Orleans to Paris, France, radio from Paris to the Pentagon Building at Washington, D.C., and land line from the Pentagon to Tobyhanna. Switches were provided so that the Transceiver operators at Orleans and Tobyhanna could "talk" by printing telegraph when card transmission was not taking place.

Traffic in the reverse direction, that is, from Tobyhanna to Orleans, consisted mainly of changes in part numbers, new supply items, etc.

A press release from the Pentagon, after the system had been in operation a few months, stated that the trials indicated a saving of up to 25 days in administrative handling and transmission times.

The trial installation was so successful that in July, 1955 the Signal Corps announced that the radio transmissions were now standard procedure.

The Signal Corps subsequently installed Transceivers at other supply depots at Lexington, Kentucky, Decatur, Illinois and Sacramento, California. Machines were also installed at the Signal Supply Agency at Philadelphia, Pennsylvania. These machines operated over voice telephone channels. A 704 was installed at Philadelphia to keep inventory records for the depots.

* * * * * * * * * * * * * * *

At the present time there are four Transceivers at Tobyhanna which transmit to dozens of cities. The trans-Atlantic radio transmissions are now handled from New York instead of direct from Tobyhanna. A trans-Pacific link has been installed from Fort Mason, (Sacramento) California to Japan.

The volume of traffic on the network has increased to the point where it is now estimated that 60% of all Army overseas requisitions are handled by Transceivers. A write-up of this extensive system is beyond the scope of these notes. For the month of July 1960 there were more than 17,000 cards transmitted overseas from Tobyhanna alone.

SECTION 3G

ARMY OVERSEAS PERSONNEL REQUISITIONS

In 1956 the United States Army put into operation a system whereby European Headquarters could requisition men from the United States by overseas radio transmission using Transceivers. It is estimated that the system saved $10,000,000 a year and resulted in improved morale of the men involved.

The following write-up of the system appeared in the New York Herald Tribune on June 26, 1956 under the caption:

"BRAIN ROBOT HELPS FILL ARMY NEEDS"

"Heidelberg, Germany (AP)

" - With a minimum of fanfare, the United States has put into operation the closest thing yet to a robot army.

"It's all done with electronic brains and little cards with a lot of punch marks.

"Not that the machines do anything quite so frivolous, but if it was urgent they could find a twenty-five-year-old cook with blue eyes, brown hair and an appendix scar in the United States as a replacement and have him in southern Germany in forty-eight hours.

"The gadget that does the work is called a 'Transceiver.' It knocks holes in a card at the United States Army European headquarters here and at the same time, by trans-ocean radio, stamps the same holes in a card at Fort Dix, N. J., where European replacements are selected.

"In the old days, the replacements were shipped over by the boatload. The replacements landed at Bremerhaven and went 450 miles by train to Zweibrucken. There they spent three days getting placed and, in some cases, wound up back at Bremerhaven.

"None of that any more. Army headquarters here keeps up a continuing file on what replacements are needed for the quarter million United States soldiers in Europe.

"As soon as some one is transferred, dies, goes over the hill or what have you, the Army machine rattles off a card saying what is needed.

"At the same time, Fort Dix collects cards on personnel available for overseas duty.

"These cards are slammed together in another machine and out comes the replacement right there on a card. The card even contains his orders. Fort Dix interviewers take a few moments to confirm the machine, but it's almost never wrong.

"Thus, Heidelberg can ask for a replacement on Friday and he can be flown to his new station by Sunday.

"Brig. Gen. Bruce Easley, Adjutant General at Heidelberg headquarters, said the machine not only saves some $10,000,000 a year but that it insures against misuse of man power, saves headaches for the GI s and could be mighty helpful in an atomic war.

"In an A-war, for instance, Gen. Easley said: 'We believe that in the event of an emergency, units will be so depleted due to atomic action that it will be impossible to reconstitute them and refit them for combat in the theater of operation. Therefore, we feel we must look toward unit replacement to fill these gaps.'

"Heidelberg's human brains are busy right now trying to plan the best war time application of the Transceiver.

"As for the GI himself, Gen. Easley said:

" 'It improves morale. I think that's obvious. The soldier knows his unit assignment before he leaves Fort Dix. It certainly expedites mail delivery . . . shoulder patches are issued and the soldier enjoys a sense of belonging prior to his departure.'

"The Transceiver has handled some 40,000 replacements since it went into operation last fall. Now the Army is trying to set up a massive Transceiver card catalog file that would enable the Pentagon to put its finger on any of its men, anywhere in the world."

SECTION 3H

THE CHICAGO & NORTH WESTERN RAILWAY CO.

The Chicago & North Western mechanized card reporting and accounting system began full-scale operation on January 1, 1959. The system is known as "CAR-FAX."

In this installation Transceivers are used to accomplish direct card-to-card transmission over telephone channels and such documents as interchange reports, train consists, switch lists, etc., are printed off-line by IBM accounting machines. In the New Haven installation described in Section 2D, the card-to-tape and tape-to-card system is used over telegraph channels and the reports referred to above are printed on-line using telegraph page printers. The advantages of mechanization on the Chicago & North Western are essentially the same as outlined in detail for the New Haven Railroad (Section 2D).

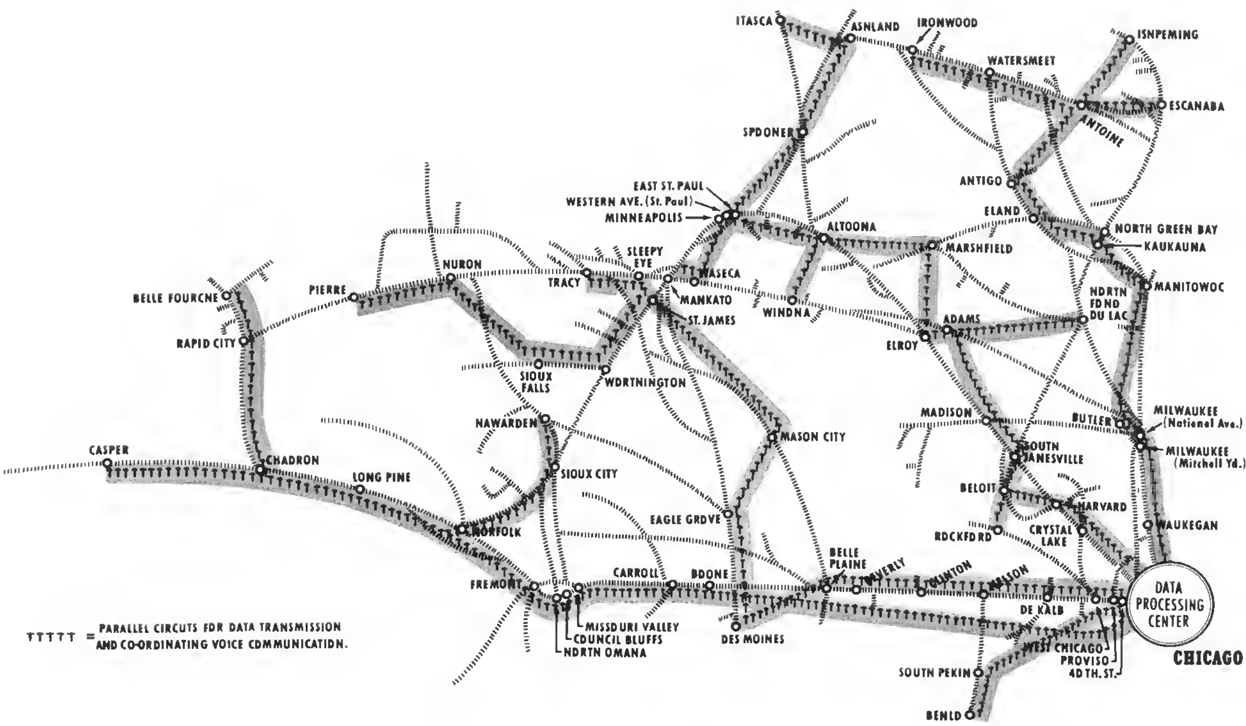
The information covered in the remainder of this section was extracted from a report prepared by Arthur Anderson & Co. under date of November 1959. This report states that, "This is the most advanced integrated data processing system in operation on any major railroad. For the first time, operating requirements for car distribution information, traffic requirements for tracing information and shipper analysis data, and accounting requirements for per diem and revenue data have been integrated into one reporting system. CAR-FAX includes the largest commercial Transceiver installation in the world — only the system in use by the U. S. Air Force is larger in size and scope."

The Chicago & North Western installation includes mechanized equipment at 68 strategic yards (the communication network comprising almost 9,400 miles of roadway) which are linked with a central data processing center at Ravenswood office in Chicago. The map on page 51 shows the locations included in the system.

The equipment in the yards is tailored to each yard's requirements. Several yards with very low volume have only one unit, a Transceiver with a keyboard. Thirty-seven yards are equipped with accounting machines to print interchange listings, wheel reports, train consists and switch lists.

The system comprises the following IBM equipment, at an annual rental of approximately $600,000.

68 Yard Offices:	No. Units
26 Card punches	80
66 Transceivers	24
66 Transceivers with card punch keyboards	46
402 Accounting machines	38



Chicago & North Western's Circuit Layout for Transceiver Operation

Ravenswood Data Processing Center:		No. Units
66	Transceivers	20
407	Accounting machines	5
83	Sorters	6
77	Collators	7
101	Statistical machines	2
528	Accumulating reproducers	2
604	Calculators	2
514	Reproducers	2
557	Interpreter	1
26	Card punches	2
63	Card-controlled tape punch	2

The communication network consists of five leased telephone circuits for data transmission with five parallel circuits for voice communication. The annual cost of these circuits is approximately $300,000. Transceivers are equipped to operate on one of four different frequencies so that each circuit permits four simultaneous transmissions. Several yards on each circuit are assigned to each of the four frequencies which means that each circuit is divided into four party lines for Transceiver operations. All yards on each circuit share the parallel voice circuit. The Transceiver arrangement is as follows:

1. Twenty Transceivers are located in the Ravenswood office. Four Transceivers, each equipped to operate on one of the four frequencies, are connected to each of the five circuits.

2. Seventy Transceivers are located in the sixty-eight mechanized yards (two units at Proviso and Butler). Each Transceiver can receive from or send to only the one Transceiver in the Ravenswood office which is connected to the same circuit and equipped to operate on the same frequency.

All use of the network is supervised by controlling the circuit connections from the Ravenswood office. When a yard office is ready to transmit, the voice circuit is used to request a connection. When the Ravenswood office is ready to send advance train consists to the destination yards, the voice circuit is used to make the necessary arrangements. Since advance train consists are relayed through the Ravenswood office, there are no direct transmissions from yard to yard.

Some comments on the selection of Transceivers rather than telegraph printers for data transmission follow: At the time this system was designed three basic types of systems could have been installed — (1) an all punched-card system using Transceivers, (2) an all Teletype system, and (3) a combination punched-card and Teletype system. The outstanding advantages of the all punched-card system using Transceivers which were the basis for this decision are:

1. The relative simplicity of an all punched-card system was of particular significance because of the employee training problem.

2. The accuracy of data transmission provided by the Transceiver was very important especially because of the transmission of data for revenue and car accounting purposes.

3. The cost of the all punched-card system, including personnel requirements, was estimated to be less than either of the other two systems.

Generally, the sixty-eight mechanized yards are all of the important crew-change points or terminal yards on the North Western. Mechanization of terminal yards provides for reporting the departure and arrival of trains at these yards. With few exceptions, the terminal yards also are the major loading and interchange stations. These sixty-eight yards on the North Western cover 97% of the train movements, 82% of the interchange and slightly over half of the on-line loading.

The system has been designed on the basis that a detailed card will be key punched for each load, or each empty movement, upon arrival of the car at

any one of the sixty-eight mechanized yards. By the use of report "header cards" and "divider cards" to accompany each transmission of data from detailed cards and by relay from yard to yard through the Ravenswood office the initial key punching for each car serves all subsequent purposes.

CAR-FAX data processing is a large volume operation, the daily input received via the twenty Transceivers at Ravenswood approximating 75,000 to 100,000 cards. The daily updating of a master file of cars on line is the main phase of car movement data processing. This file averages about 50,000 cards and is updated with approximately 30,000 transactions daily between midnight and 6:00 a.m. This file contains a card for each car showing the last reported location, the previous station at, reference to the previous move, cumulative mileage, etc.

For a list of the reports developed in the processing center and a complete description of the many different card forms, how they are developed and used, the reader should consult the Anderson report referred to at the beginning of this Section.

SECTION 31

FIRESTONE TIRE & RUBBER CO.
(DIAL-UP TRANSMISSION)

Firestone Tire & Rubber Company began testing Transceivers on regular dial-up telephone channels in November 1958. In order to provide for operation over these facilities, the Transceivers were modified so that information was fed to and received from Digital Subsets (FM signaling devices) which were developed by A. T. & T. These Subsets replaced the equipment incorporated in Transceivers for signaling over private wire telephone channels. These tests were the first regular transmissions using Transceivers to be made over dial-up facilities.

The first transmissions took place between Akron, Ohio and Los Angeles, California. They proved to be successful and the system was enlarged to include additional field accounting offices at Atlanta, Dallas and Kansas City. Mr. Victor R. Clary, Divisional Manager of Firestone's sales accounting and data processing departments, explains the system in this manner: "We had a difficult problem. It would have been too expensive to have our own leased telephone wires to Los Angeles and the other points. Our new system gives us a toll program whereby we pay for the lines only when in use. The information is vital to such a widespread operation as ours and unless it is timely it is of little value to management."

Payroll cards are mailed from numerous locations each Friday to the field accounting offices. These cards are transmitted to Akron, Ohio for processing. Accounting data for retail stores operations are keypunched into cards at the field offices and likewise transmitted to Akron.

The data are processed in an IBM 705 computer.

Firestone has several other Transceivers which operate over private wire facilities.

SECTION 4A

HIGH SPEED BUFFER-TO-BUFFER TRANSMISSION (THE DATACOM SYSTEM)

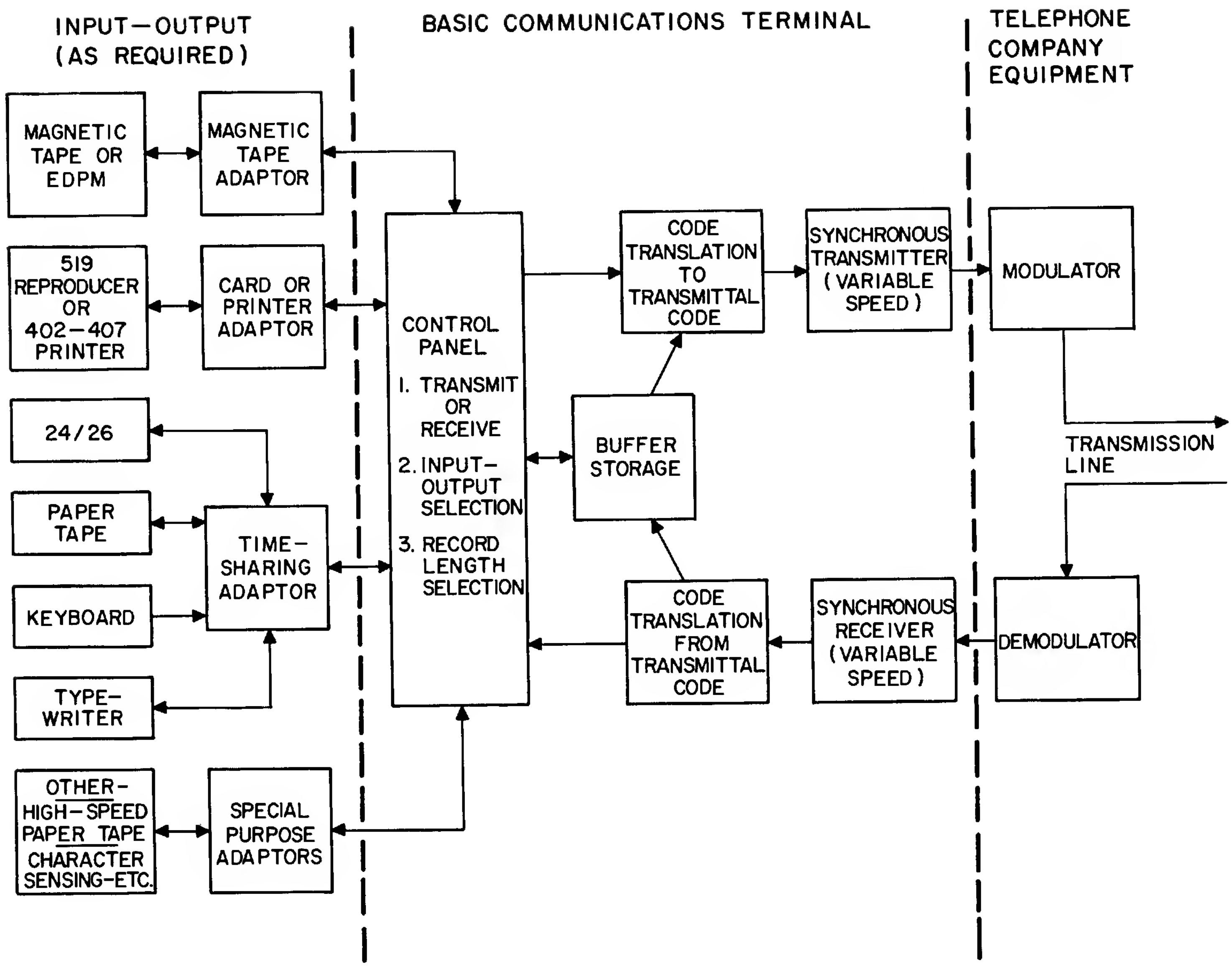
Following release to production of the Data Transceiver, considerable study was given to the type of equipment which IBM should market next in order to maintain the leadership in data transmission it had enjoyed since 1941, first with the introduction of card-to-tape and tape-to-card equipment and, subsequently in 1954, with the introduction of the card-to-card Data Transceiver.

While, in general, batch data transmission requirements were being met to a satisfactory degree at that time by column-by-column paper tape and card equipment, higher speeds and communication between a wide choice of input-output devices were considered to be definite future requirements.

Paper tape transmission over telegraph channels utilized approximately one-twelfth the bandwidth of a voice telephone channel and the Transceivers (one pair of machines) utilized one-quarter the bandwidth of a voice telephone channel. The next logical step was to develop machines which would utilize the full bandwidth of a standard voice telephone channel. This would, at the state of the art of modulation-demodulation equipment in 1956-7, permit signaling over voice telephone lines (private) at 750 or 1000 bits per second, which is equivalent to 93 or 125 characters a second respectively when an eight-bit transmission code is used.

A set of machines which would meet these objectives was first proposed in specifications dated October 22, 1956. The name "DATACOM" (short for data communication) was proposed for the line of equipment specified, but it was not acceptable for copyright in the opinion of the Patent Department because it was too descriptive. It is now being used by Automatic Electric Company, a subsidiary of General Telephone. At the January 9, 1957 meeting of RETMA, (now EIA) Mr. Anderson and Mr. Berger of Headquarters, U.S. Air Force, presented an "Air Force Proposal for Improved Data Communications" which advocated the development of basically the same equipment covered by the October 1956 specifications. The name the Air Force proposed for the equipment was "DATACOMM."

The diagram, page 56, shows the principal elements which were proposed for the Datacom system and the input-output devices between which communication would be possible. It was proposed to develop one basic type of terminal equipment which would include a buffer, a code translator and a synchronous transmitter-receiver (STR). These elements would provide basic terminal equipment which would be the same irrespective of the input-output equipment used.



Principal Elements Proposed for the IBM Datacom System

The concept of "universal" terminal equipment was proposed because special treatment of each customer requirement as it arose would involve a virtually continuous and very expensive development program.

Between the terminal and input-output devices, specially designed adaptors would be used to coordinate the operation of the two mechanisms. In the case of magnetic tape, the adaptor would consist primarily of tape motion controls since the buffer storage means would use the magnetic tape code. In the case of parallel card machines, the adaptor would convert from parallel operation to serial operation and translate the card code to the magnetic tape code used in the buffer. In the case of slow speed machines, such as typewriters, 024 punches, etc., the adaptors would also provide for several machines to time-share the transmission facility so that full advantage of its signaling capacity could be realized.

With the universal terminal equipment, it would be possible for any input device to communicate with any output device.

Some of the options are listed below:

1. Magnetic tape to magnetic tape
2. Card to card
3. Magnetic tape to card
4. Card to magnetic tape
5. Magnetic tape to printer
6. Card to printer

For the initial development stage it was planned to provide for the first four types of transmission.

In order to keep the IBM development cost and the cost of communication to the customer to a minimum it was planned to use card and magnetic tape equipment already in production and most commonly found in customer installations, viz., IBM 519 card reproducers and IBM 727 magnetic tape frames. This would make it possible to time-share the equipment where full-time transmission was not involved.

It was proposed that the terminal equipment be designed for operation over standard voice telephone channels as the first application, but that it would provide for transmission at much higher speeds, e.g., up to magnetic tape speeds of 15,000 characters a second which requires a bandwidth considerably wider than a voice telephone channel. Facilities which provide this capacity are available in the form of coaxial cable and microwave radio circuits.

Technology has increased rapidly since the proposal was made in 1956. Specifically, A. T. & T. has developed new modulation-demodulation equipment

which has now increased the signaling speed on message (toll) channels from 600 to 1200 bits per second and up to 2000 bits per second on private wire channels. Collins Radio, Stromberg Carlson, Rixon and others have developed equipment which provides for signaling at still higher speeds.

The STR and core buffer were practically completed in tube logic at the time the decision was made in 1957 to use solid state devices in all new laboratory developments. Work on producing an STR in solid state logic was undertaken, and a working model was completed in 1958. Work on a card adaptor (for use with an IBM 519 Reproducer) and the buffer was started but never completed.

With the advent of the incremental tape and the high speed serial reader-punch developments, the money which Engineering requested to continue the Datacom development was not forthcoming (except for STR) because it was believed in some quarters that incremental devices, specifically the incremental magnetic tape and serial reader/punch, could be operated at speeds to match the transmission capacity of a telephone channel and thus obviate the need for buffering. While the speed of the incremental tape drive approximated the signaling speed of a voice telephone channel at that time (150 characters per second) this concept did not take into consideration any improvement which might be made in modulation-demodulation techniques which would increase the line speed. By the time the incremental tape machine (IBM 7701) could be developed, the speed of the lines had doubled. A supplementary development program is now under way to increase the speed of the IBM 7701 to approximately 300 characters per second. Further development will be required if we are to market tape equipment to operate at still higher speed, say 15, 000 characters per second or more.

Also, the serial reader/punch, described in Section 6, will utilize a buffer to match its speed to that of the lines and to improve operating efficiency. This machine will operate at 50 cards per minute, when all 80 columns are transmitted for card-to-card operation. Further development will be necessary to accomplish card-to-card transmission in the 90-100 card per minute range.

In addition to matching the speed of input-output devices to the transmission lines, buffers can play an important role in grouping records to form one large block of data, for example, a group of 1000 characters. Only in this way can the speed capabilities of half-duplex lines be realized (90% or better) when transmitting cards or short tape records because of the time lost in turning the line around to acknowledge receipt of each record.

The IBM 7701 and the serial reader/punch both use the STR developed under the Datacom project.

SECTION 4B

THE SYNCHRONOUS TRANSMITTER-RECEIVER

The Synchronous Transmitter-Receiver (STR) is a device which will provide fast and accurate transmission of data between two remotely located input-output devices such as card reader-punches, tape drives, or computers. One STR is used at each location.

The STR serves to connect the input-output equipment to the transmission medium, such as telephone lines (toll or private), telegraph lines, or radio circuits. The connection is made through modulation-demodulation equipment provided by the communication companies (A. T. & T. or Western Union, for example). The connections specified in EIA Recommended Standard 232, entitled "Interconnection of Data Terminal Equipment with a Communication Channel" are provided.

Classified as a second level product, the STR can be used in a wide variety of applications. The STR includes two SMS gates of logic, but not covers, operating controls, or power.

The original design of the STR was capable of operating at a speed of approximately 15,000 characters per second. When the Datacom project (Section 4A) was abandoned in favor of incremental magnetic tape and serial card reader-punch equipment, the STR was redesigned to operate at a slower speed, at reduced cost. It is now capable of operating at approximately 4,800 bits (600 characters) per second.

The STR is a solid state unit using transistors and cores to insure maximum life with minimum maintenance.

The first application of this device was in the Incremental Magnetic Tape Terminal (IBM 7701). Other applications include the IBM 1009 Data Transmission Unit for connecting transmission channels to computers and the Card Transmission Terminal (using the Serial Reader-Punch) which is under development at Poughkeepsie at the present time. Because it can be used with a wide variety of input-output equipment and with various types of transmission media, the STR probably will find wide application for connecting various IBM machines to data transmission facilities.

Following is a brief description of the operation and principal features of the device.

Mode of Operation

The STR consists of a transmitting section and a receiving section, each independent of the other, permitting the device to transmit and receive simultaneously.

The transmitting function of STR calls for characters from the input device, one at a time; checks them to make certain that they are valid characters; changes the character code of the input device to a 4 of 8 transmission code; serializes the character and feeds the bits to a modulator (not a part of the STR) for transmission over the communication channel. Longitudinal redundancy check data (LRC) are accumulated for transmission to the receiver as an additional transmission check.

The receiving function of STR accepts the serial bits from a demodulator (not a part of STR); accumulates the bits to form a character; checks for four 1's and four 0's (4 of 8 count) translates each character to an output code, and then feeds the data to an output device, one character at a time. An LRC accumulation is made, and at the end of each record it is checked for agreement with the LRC sent from the transmitter.

A master oscillator is used to sequence the operation, and to provide the necessary stability to keep the transmitting and receiving terminals in step.

Additional functions include control of modulation-demodulation equipment, change of direction on half-duplex circuits, and control of input/output devices to effect re-transmission when the data are not received correctly. The STR also includes lines to control the operation of input/output equipment.

Synchronous vs. Start-Stop Transmission

In the synchronous type of transmission, the code bits of one character are immediately followed by the code bits of the next character. The synchronous form of transmission is therefore more efficient than the commonly used start-stop system in which each character is preceded by a start signal and followed by a stop signal.

Furthermore, the synchronous system can be used at higher speeds because it can tolerate considerably more jitter and distortion on the transmission link.

In the start-stop system, synchronism between the transmitting and receiving terminals must be maintained for one character only. In the STR, synchronism is maintained for several seconds in the absence of signals so that the terminals do not require re-synchronization during line turn-around time (400 milliseconds on telephone lines), and minor interruptions of the transmission link. For this purpose, the STR is controlled by a precision crystal oscillator of at least ten parts per million tolerance.

The receiver is automatically kept in synchronism with the transmitter by means of a clock which has provision for introducing phase corrections. Phase information is obtained by the signal transitions during normal operation, or by idle signals when the machines are not transferring data.

Half and Full-Duplex Operation

The STR contains a transmitting and a receiving section, and will operate on either half-duplex or full-duplex types of circuits. On full-duplex circuits and with suitable terminal equipment, two transmissions (one in each direction) can take place simultaneously. On half-duplex circuits the transmission is limited to one direction at a time.

Accuracy Checks

Four checks are provided on the accuracy of operation of the STR and the communication link:

1. The use of a fixed-count transmission code which provides a means for checking received data.

2. LRC check.

3. A check which prevents the receipt of duplicate records, or the loss of records, at the receiving terminal.

4. Checks which prevent the STR from accepting characters which are not considered "legitimate" for the operation of the input-output devices in use.

The STR includes input lines so that failures of the input or output device can be recognized for appropriate action. It also has output lines so that errors which occur in the input equipment, the output equipment, or during transmission can be indicated by lights and alarms.

Clocks

All timing pulses in the STR are generated by a precision crystal-controlled oscillator. The transmitting and the receiving timings for both the sending and receiving terminals are obtained by counting down from the oscillator. The receiving clock includes a digital phase correction circuit for automatic synchronization of the receiver clock to the received signals.

Core Code Translators

The STR uses core logic for code translation, and by proper wiring (or changing translators), it can handle magnetic tape, card, paper tape, or other

input-output codes. The transmission code then becomes a common language between STR units attached to input-output devices using different codes. The translators may be wired for any desired transmission code, providing there are six codes available in addition to the character set. These six codes are required for control signals. The code used in the standard STR is the fixed count 4 of 8, which has 70 code combinations. This leaves 64 codes available for assignment to data. The 4 of 8 code will detect all errors involving an odd number of bits, and all even additions or deletions of bits, except for transposition of bits within a character. This latter type of error will be detected by the LRC check, unless there is an even number of the same errors, involving the same bit positions, within a record.

Cores are also used for "housekeeping" functions.

Automatic Re-Transmission

Provision is included for automatic re-transmission of records which are received in error because of noise or interruption of the transmission link. This results in speeding up the overall operation because the operators are not alerted until three successive failures have occurred.

SECTION 4C

HIGH SPEED COMPETITIVE EQUIPMENT

Collins

Collins Radio Company has developed magnetic tape-to-magnetic tape (Kinetape) and card-to-card (Kinecard) equipment. This equipment employs a unique system of phase modulation and signal detection which provides high speed signaling. Improved immunity to noise is claimed.

The speed of operation of the model TE-206 is 300 bits per second per channel or 2400 bits per second for a total of 8 channels.

The type of modulation used requires that the lines be treated to a delay equalization tolerance of one millisecond between 400 and 2700 cycles per second. For this reason it does not appear practical to use this system on toll (dial) circuits at the 2400 bits per second rate.

The Kinetape Converter is designed for the transmission of magnetic tape information at a maximum rate of 300 seven-bit characters per second. Errors in transmission due to noise on the lines, etc., are detected by parity checks and corrections are made by automatic retransmission of the block containing the error. The blocks are 120 characters long (maximum).

The Kinecard system employs IBM 523 Gang Summary Punches capable of reading and punching at the rate of 100 cards per minute.

Information is transmitted row-by-row using ten eight-bit "bytes" for a total of 80 bits per row (one for each column of the card). With this method of operation, it is necessary to transmit a bit for every punching position of the cards (960) irrespective of the number of columns punched. Including check bits and lost time, the time required to transmit approximately 1440 bits is consumed.

At the receiving end, a five-row buffer (400 bits) is used to synchronize the speed of the incoming data to the card punch.

This type of operation requires that the card reading and punching speed and the signaling speed must all be synchronized. With the TE-206 and the IBM 523 punches, the rate is approximately 93 cards per minute.

In the Kinecard system, the cards are transmitted in groups of 400-500. If errors are encountered, the cards are offset stacked at the receiver. At the

end of each group of cards, the operators check by telephone, and whenever an error is encountered, the entire group is retransmitted.

Approximately two years ago, the Collins Kinecard equipment was field tested in a military application. Although the nominal (advertised) card production rate is 100 cards per minute, the actual net production was approximately 65 cards per minute.

Additional tests were recently made for the Signal Corps and Chrysler.

A test of Collins Kinecard equipment is now under way between Washington, D. C. and England. The purpose of this test is to determine the ability of the equipment to operate over a channel of the trans-Atlantic telephone cable.

One serious deficiency in the Collins design approach is that while card-to-card and magnetic tape-to-magnetic tape transmission is possible, no provision has been made for communication between cards and magnetic tapes, which is felt by IBM to be the large application.

Stromberg Carlson

Stromberg Carlson presented a paper at the June 21, 1960 meeting of the AIEE at Atlantic City, New Jersey, in which they described a card-to-magnetic tape system which operates at a speed of 2400 bits per second.

The Stromberg Carlson system employs an IBM 523 Gang Summary Punch to read the cards at the transmitter. This machine is capable of reading cards at the rate of 100 per minute. At the receiving end of the circuit, the data are recorded on seven-track magnetic tape.

Information is transmitted row-by-row using an 80-bit buffer (one bit for each column of the card). With this method of operation it is necessary to transmit a bit for every punching position of the cards (960) irrespective of the number of columns punched. Including check bits and time lost between cards the total is approximately 1440 bits.

The information in the 80-bit buffer is read out serially, six bits at a time, redundancy is added, and the data are transmitted serially in seven bit groups. At the receiver, the bits are assembled in a seven-bit register for recording on the tape.

It will be noted that in this system the card information is not assembled on the tape in character language, but rather in groups of bits. The computer on which the tape is read must be programmed to unscramble the data.

The cards are transmitted in groups of 200 followed by a verbal verification of the accuracy of transmission similar to the Collins Kinecard procedure.

More recently, Stromberg has announced card-to-card and magnetic tape-to-printer transmission. The speed of card-to-card transmission is not specified in the announcement. Magnetic tape-to-printer operation over a telephone channel is at the rate of 350 characters per second.

Philco

Philco has recently announced buffer-to-buffer transmission at rates up to 340 characters per second over telephone channels. Various input-output devices can be used. The buffer capacity is 1024 characters and transmissions up to almost 1,000,000 bits per second on suitable communication channels are possible.

The concept of buffer-to-buffer transmission with various types of input-output equipment is identical to the work on the Datacom system which IBM had under development several years ago, as described in Section 4A.

** ************

Sperry Rand developed equipment in 1957 known as "Transrecorder" for magnetic tape-to-magnetic tape transmission. The writer has no knowledge of any installations having been made.

Comment

With the method of operation employed in Collins card-to-card and the Stromberg card-to-tape systems, the speed at which card data can be transmitted is fixed at between 90 and 100 cards per minute.

With a buffered serial system, such as the Philco system described in this Section and the Datacom system described in Section 4A, the number of bits transmitted would be approximately 650 per card (as compared to 1440) assuming all 80 columns were transmitted. If only 40 columns were transmitted the figure would be approximately 325 bits per card, etc.

Therefore, while both the Collins and Stromberg systems feature a high signaling speed, (2400 bits per second) both systems are extremely wasteful of line capacity. The amount of useful information conveyed is only one-half the information capacity of the transmission link. In other words, a serial transmission system operating at 1200 bits per second would, with a buffer, convey the same amount of information. In addition, a 1200-bit serial buffered system would be capable of transmitting sufficient information to punch 100 eighty column, 196 forty column, or 388 twenty column cards per minute, or to record the corresponding amount of data on magnetic tape.

SECTION 5

THE IBM 7701 MAGNETIC TAPE TRANSMISSION TERMINAL

Magnetic tape-to-magnetic tape transmission using the IBM 7701 Magnetic Tape Transmission Terminal was announced in March 1960.

The terminal is assembled in two vertically mounted SMS cubes. The upper cube contains the tape transport and its control unit, the operator's panel, and a customer engineering panel. The lower cube contains the synchronous transmitter-receiver (STR) described in Section 4B, the magnetic tape terminal adaptor to couple the tape unit to the STR, and power supplies.

Two complete terminals are required to effect magnetic tape-to-magnetic tape transmission, one at each end of a transmission link. The necessary modulation and demodulation equipment which must be used for signaling will usually be provided by the communication company renting the transmission link.

The IBM 7701 Magnetic Tape Transmission Terminal is designed primarily for operation on either message toll (dial) or leased wire lines. However, it will operate on any equivalent transmission facility. Input-output connections conform to specifications of the Electronics Industries Association's Recommended Standard 232.

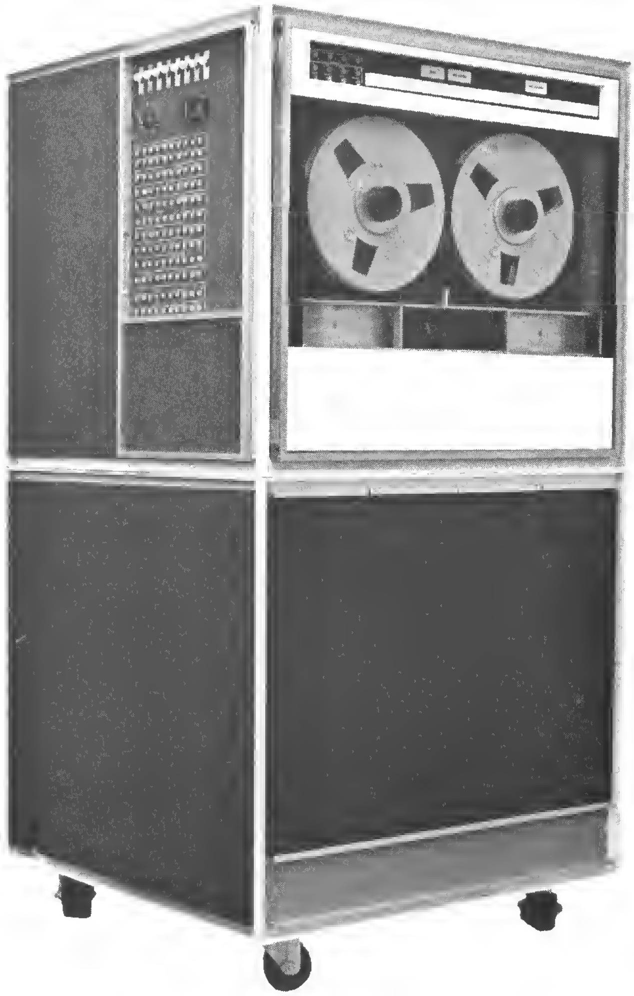
Transmission rates at 600 and 1200 bits per second (which correspond to character transmission rates of 75 and 150 characters per second) are provided.

The 7701 reads and writes tape with a character density of 200 per inch. Thus it is able to read tapes prepared on the 727, 729-I, 729-II and 729-IV Magnetic Tape Units as well as to write tapes for use on these units.

The IBM 7701 will read or write magnetic tapes in either binary or binary-coded-decimal form. It checks that characters read during transmission are valid, that the transmission has been accomplished accurately, and that the characters recorded in the tape at the receiving terminal are valid. Three successive attempts will be made to effect accurate transmission of a record before the operators are alerted.

Records of any length may be transmitted and written on this equipment.

Tape is moved by a unique stepping motor in increments of 0.005 inch while reading or writing. To increase the effective speed of the system, tape is moved through load point delays and inter-record gaps at a constant speed of 15 inches per second by a continuously rotating capstan drive.



The IBM 7701 Magnetic Tape Transmission Terminal is a completely transistorized system designed to transmit from magnetic tape to magnetic tape over telephone lines.

A new type of read head, called a probe flux sensitive head, is used. This head permits a character to be read from tape while tape is stopped or moving slowly over the read head. This departs from the reading method of other IBM tape systems, which requires tape to be moved at a relatively high speed.

Test facilities are included in each Terminal for use in localizing trouble to the machine transmitting, the machine receiving, or the transmission facility.

This machine can communicate with the Serial Reader-Punch equipment described in Section 6 to provide Magnetic tape-to-card or card-to-magnetic tape transmission.

SECTION 6

CARD TRANSMISSION TERMINAL WITH SERIAL READER-PUNCH

There is under development in the Data Systems Division at Poughkeepsie, New York, a Card Transmission Terminal based on the use of a serial reader-punch which has been developed at San Jose. It is expected that the machine will be announced early in 1961.

The Terminal will be compatible with the IBM 7701 Magnetic Tape Transmission Terminal, which was announced in March 1960, in that card-to-magnetic tape and magnetic tape-to-card transmission are provided in addition to direct card-to-card transmission.

The Terminal comprises a serial reader-punch, the synchronous transmitter-receiver (STR), and the adaptor circuitry necessary to inter-connect the two units. The machine is assembled in a table-top cabinet. The reader-punch mechanism is located on top of the cabinet and the electronic gates and power supplies are below.

The Terminal is designed primarily for operation on voice telephone channels of both the toll (dial) and private line types, but will operate on any equivalent transmission facility. Character transmission rates of 75 and 150 characters per second are provided to match the speeds of the IBM 7701 Magnetic Tape Transmission Terminal.

A small buffer (four card capacity) is used to match the speed of the reader and punch functions to that of the transmission line and to obtain automatic re-transmission of the card data when a transmission error occurs. This avoids backing the cards up for re-reading, and the punching of erroneous information in cards at the receiver.

When transmitting, the card reading speed will be 700 columns per second which is equivalent to 320 cards per minute. When receiving, the machine will punch at the rate of 50 eighty-column cards, 87 forty-column cards or 137 twenty-column cards per minute, assuming that the punchings, in the case of the 40 and 20-column cards are all in card columns 1-40 and 1-20 respectively.

The Terminal is not equipped with modulation and demodulation equipment. This must be provided by the user, usually obtainable from the communication company furnishing the transmission link. The connections specified in Electronic Industries Association Recommended Standard 232 are provided in the terminal for connecting to the modulation-demodulation equipment.

The machine is equipped to detect card reading errors in that invalid codes read from the cards will be rejected. Also the machine can be programmed for blank column detection to insure correct reading of numerical data. Card punching is checked by sensing that the correct punch or punches were actuated and by blank column detection circuitry. The machine is arranged to detect errors in transmission and to re-transmit up to two additional times before the operators are alerted.

Upon completion of Product Test the machine will be turned over to the General Products Division for manufacture.

SECTION 7

COMPUTER COMMUNICATIONS TERMINAL

The Computer Communications Terminal (CCT) was developed to provide data transmission on-line between computers, and off-line with magnetic tape and/or card input-output from a small machine, such as the IBM 1401. In addition to this, the CCT would provide data transmission between computers and magnetic tape and computer and cards because of its compatibility with the IBM 7701 and the Card Transmission Terminals described in Sections 5 and 6 respectively.

CCT comprises a synchronous transmitter-receiver (STR) and the circuitry necessary to connect the STR to a computer. The added circuitry includes an operator's panel and a panel to be used by Customer Engineers to facilitate servicing.

The device consists of one SMS cube which houses the STR, the interconnection circuitry and power. The operator and Customer Engineering panels are located in a superstructure mounted on top of the cube.

The connections specified in Electronic Industries Association Recommended Standard 232 are provided so that the Terminal can be connected to modulation-demodulation equipment furnished by the user usually from the communication companies. This will provide for operation over dial-up or private line telephone circuits or the equivalent.

Character transmission rates of 75 or 150 per second are provided as standard. The machine is arranged to detect errors in transmission and to retransmit up to two additional times before the operators are alerted.

The circuit logic design was completed and two models were in the later phases of development at the time the project was transferred to the General Products Division and announced by the division as the IBM 1009 Data Transmission Unit.

SECTION 8

SOME NOTES ON THE FUTURE

From the modest transmission rate of six characters per second over most telegraph channels in the early 1940's, a speed of 150 characters per second can now be accomplished over most message (toll) telephone circuits using the A. T. & T. model 3A subsets. This is twice the speed which was announced for toll circuit operation two years ago. On private telephone channels and high speed telegraph channels, the speed at which data will be capable of being transmitted in the near future will be at least twice the 1000 bits per second speed announced two years ago. Both A. T. & T. and Western Union have subsets under development which are expected to increase the signaling speed to between 2000 and 2400 bits per second.

The improvement in speed over the last few years has been made possible by advances in the design of modulation-demodulation equipment by the communication companies and as the result of extensive tests which have been conducted by A. T. & T. on their telephone channels.

The standard telephone channel as used for voice occupies a bandwidth of 4000 cycles per second. Carrier circuits over which many conversations can take place simultaneously are included in the telephone plant which could possibly be made available if there is sufficient demand for higher speed facilities. One such carrier circuit could provide a bandwidth of approximately 48,000 cycles per second, which is the equivalent of 12 voice telephone channels. A second carrier group with a bandwidth of 240,000 cycles per second could possibly be provided. This bandwidth is the equivalent of 60 voice telephone channels. While these carrier facilities could possibly be made available within the present telephone plant, they exist only between Telephone Company offices. Loop facilities to accomodate these speeds would have to be provided between the subscriber premises and the nearest Telephone Company office.

Microwave and coaxial cable facilities, which can handle considerably higher speeds, can be made available at even higher cost. Channels of this type are now in use for transmitting television pictures and may find uses in the data processing field for the transmission of computer displays and for very high-speed data transmission.

Mr. Frederick R. Kappel, President of A. T. & T., in an article in the March 9, 1959 issue of Barron's magazine stated that, "We expect that as time goes on the amount of communication between machines in different cities may be as large as the amount of communication between people." When asked how long in the future this might be, he replied, "7 to 10 years."

A. T. & T. long range plans call for an all dial-up plant with rates lower than at present. As communication lines become cheaper, more dependence will be placed on them for communication between various devices and computers, and even between computers. This may well result in more powerful computers at a few locations rather than a larger number of computers at decentralized locations. The U.S. Government has given some thought to this approach as evidenced by the following quotations from Electronic Design for June 8, 1960:

"Centralized Data Processing is being considered by the Federal Government. Officials think that it may be more efficient to set up a single data-processing agency and make it responsible for all computer activity. The agency would advise other government bodies on the best way to make use of available computer time, and it would standardize machine language so that all government data would be interchangeable. A single federal buyer for computers would, of course, constitute a major market — and selection by the government could influence other purchasers."

IBM's twenty years of experience in building data transmission terminal equipment (card-to-paper tape, paper tape-to-card, card-to-card, and magnetic tape-to-magnetic tape), testing it for operation over telegraph and telephone lines and short wave radio circuits, and observing its operation in actual customer installations, has equipped us with an equipment-building know-how not possessed by any other organization. This know-how can insure our continued leadership in the data communication field provided that we produce machines which are competitive speed-wise.

The ability to handle various kinds of input-output media (magnetic tape, cards, paper tape, printed copy, etc.) at speeds of 250 to 300 characters per second, to match the speed capabilities of standard voice telephone lines will, in the writer's opinion, meet a large majority of the requirements for several years to come. This does not mean that our development efforts should stop at this level. If IBM is to be the leader in the high speed transmission field, or at least be in a position to meet competition effectively as it arises, then we should develop machines and systems to utilize the broad-band carrier, coaxial cable and microwave facilities described in this section.

APPENDIX A

FIVE UNIT BAUDOT CODE

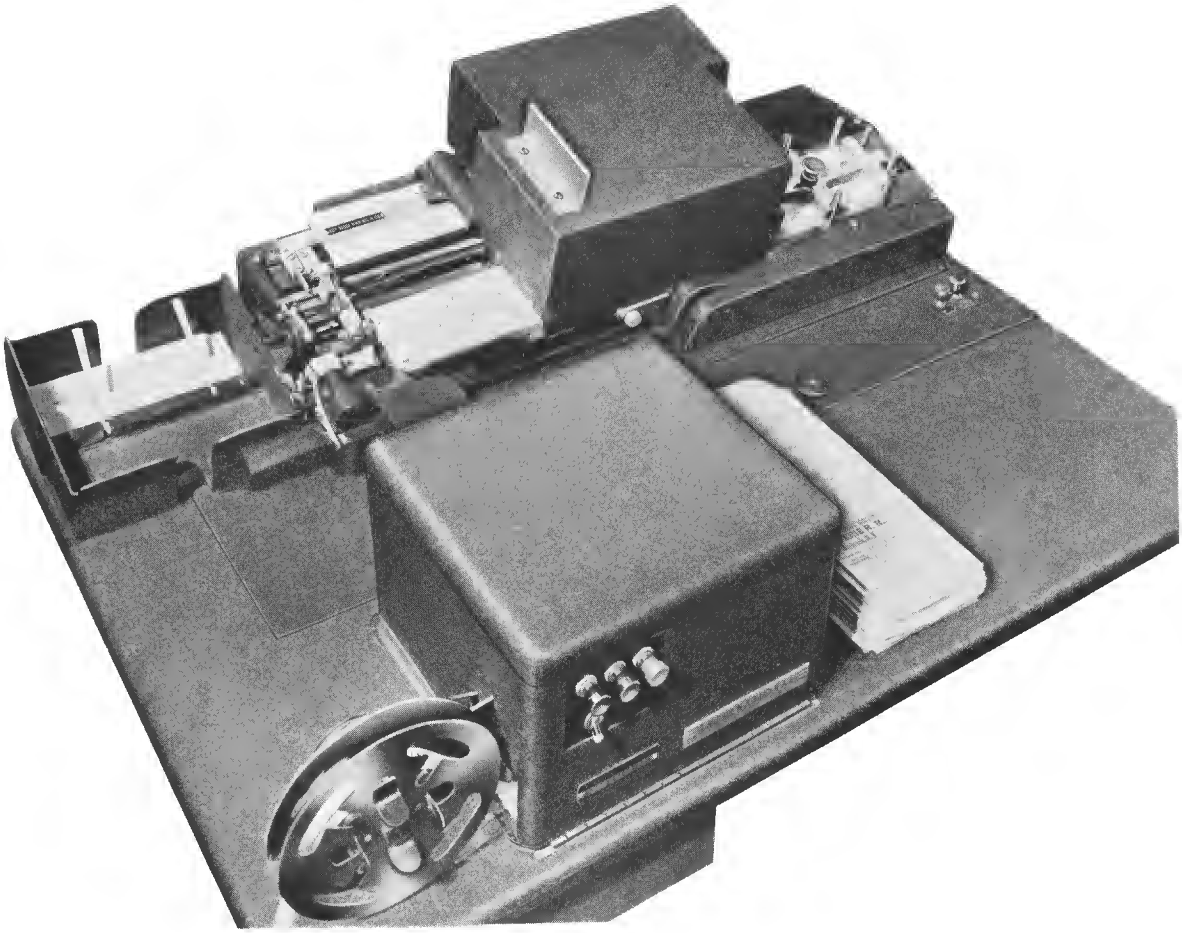
	1	2	3	4	5
A	■	■			
B	■			■	■
C		■	■	■	
D	■			■	
E and 3	■				
F	■		■	■	
G		■		■	■
H			■		■
I and 8		■	■		
J	■	■		■	
K	■	■	■	■	
L		■			■
M			■	■	■
N			■	■	
O and 9				■	■
P and 0		■	■		■
Q and 1	■	■	■		■
R and 4		■		■	
S	■		■		
T and 5					■
U and 7	■	■	■		
V		■	■	■	■
W and 2	■	■			■
X	■		■	■	■
Y and 6	■		■		■
Z	■				■
Space			■		
Figures	■	■		■	■
Letters	■	■	■	■	■
Carriage Return				■	
Line Feed		■			

APPENDIX B

THE IBM 57 CARD-CONTROLLED TAPE PUNCH
(PRODUCTION MACHINE)

The machine was composed of two units — an IBM 54 verifier and a paper tape perforator. The two units were connected by a multi-wire cable. The verifier unit included the standard keyboards so that the machine could be used as a verifier when not being used to perforate tape.

The tape perforator was driven by a motor and the speed of rotation of the punching cam shaft was approximately 500 rpm, which resulted in a rate of punching the tape of slightly over 8 columns a second. A clutch was provided to control the movement of the tape.



The IBM 57 Card-Controlled Tape Punch

The verifier unit used brushes and a contact roll for reading the holes punched in the cards. A "high bar" was used to skip over portions of the cards which contained information which was not to be recorded in the tape, and for controlling skipping from an "x" read from the detail cards.

A prepunched master card was used in some applications to control the tape punching. In the case of the New Haven Railroad installation, when it contained an "11" punch, which coincided with an "11" punch in the detail cards, the tape was punched "figures" G which caused the telegraph printers to tabulate. A "2" hole in the master card, in coincidence with a "12" hole in the detail cards, caused a 2 hole to be punched in the tape to line-space the paper in the telegraph printer.

Before punching the tape each column of the card was read to determine if the punchings represented alphabetical or numerical information or if the column was unpunched. For the first column read from each card, and for any changes from numerals to alphabet, or vice versa, during the reading of the card, the letters or figures shift code was punched in the tape preceding the punching of the data. Whenever these changes occurred the card movement was stopped while two columns of the tape were punched — one for the alphabet or numeral control code and the other for the data code.

Carriage return and line feed signals were punched in the tape each time a card was ejected. This would cause the carriage to return and the paper to be spaced vertically on telegraph printers when used to produce hard copy of the transmissions. The signals also served to signal the end-of-the-card in the tape-to-card conversion machines.

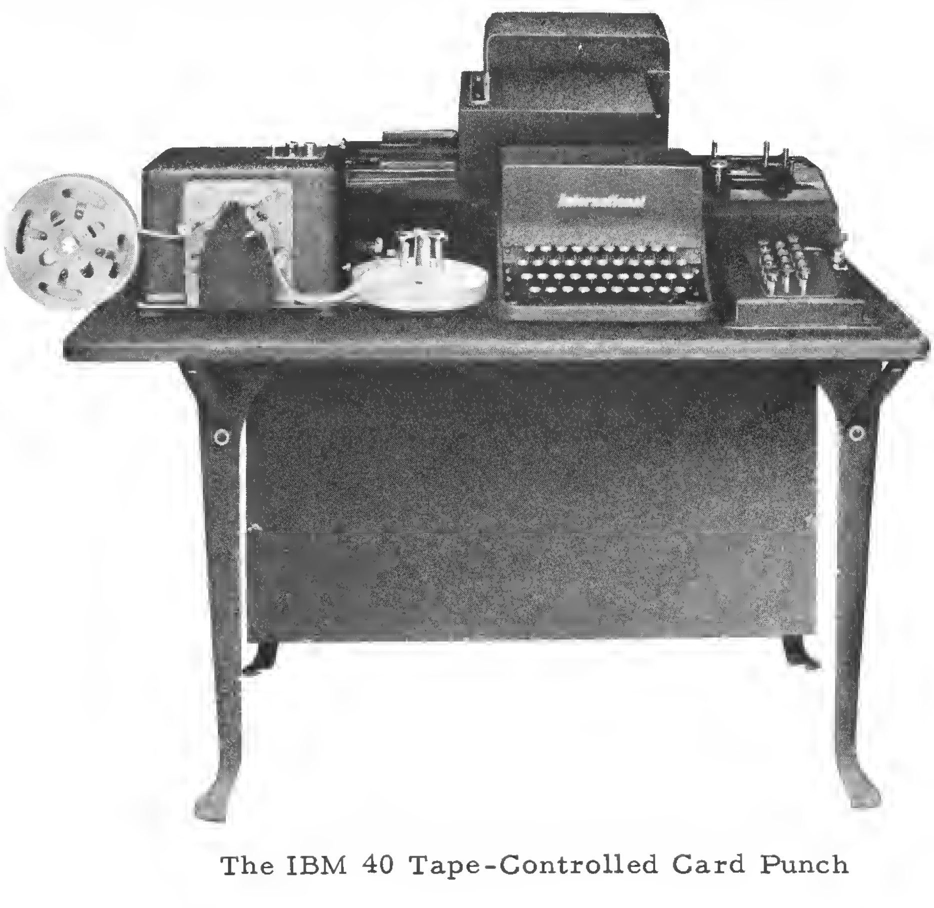
The tape perforator unit included three control buttons — start, stop, and auto feed. The auto feed button was used to record a series of letters shift codes in the tape to facilitate handling the tape in the teletype tape readers and the tape-to-card machines.

APPENDIX C

THE IBM 40 TAPE-CONTROLLED CARD PUNCH (PRODUCTION MACHINE)

The machine was composed of two units — an IBM 31 card punch and a paper tape reader. The two units were connected by a multi-wire cable. The punch unit included the standard key-punching keyboard, a small plugboard and the relays for changing from the five-hole Baudot code punched in the tape to the IBM card code.

The tape read unit was driven by a motor and the speed of rotation of the tape drive shaft was between 525 and 575 rpm. This speed resulted in moving the tape at the rate of 9 to 10 columns per second. A latch mechanism (rather than a clutch) was provided to control the movement of the tape. As long as the latch magnet was energized, the tape was fed continuously. Reading pins were used to sense the holes in the tape. They in turn controlled the coding relays for translating the tape readings to the equivalent card punchings. Start and stop keys were included in the tape read unit.



The IBM 40 Tape-Controlled Card Punch

When letters shift or figures shift codes were read from the tape, the analyzing relays were controlled to punch letters or figures in the cards.

The plugboard was used to start and stop the tape reading as follows:

Start tape reading
Stop tape reading and skip from tape - no x
Stop tape reading and skip from x in tape
Stop tape reading for high bar skip or duplicate
Last column check

The last column check feature was arranged to check the position of the card rack at the time the carriage return code was read in the tape to insure that the tape and card remained in step during the punching of each card.

The machine was arranged to be used as a key punch when not under tape control.

A punched card placed in the master card rack would result in duplicating common information in all detail cards passing through the machine.

APPENDIX D

DAYTON DAILY NEWS
DECEMBER 1, 1941

"PUNCH MACHINE KEEPS AIR FIELD TABULATIONS"

"Specially designed for the Army Air Corps, a battery of new card punching machines, the first of their kind in the world, has been installed at Wright Field to facilitate the keeping of daily balances on all equipment in the Air Corps supply depots operating throughout the United States.

"Operating from Teletype tape, the new machines do a job which would be physically impossible under the old hand filing system.

"Functioning in conjunction with the new machines is a network of Teletype machines, linking Air Corps supply depots and tactical bases of the nation with the headquarters of the materiel division at Wright Field. Through the new system the Army now gets a daily balance on all its equipment, from the Teletypes which report 40,000 changes a day in balances on individual items of equipment at individual air bases.

"Girl operators at the Teletype message center daily receive reports from 6:20 a.m. to 8 p.m. from the Army's six air depots over the continental United States, and reports from the 52 Air Corps stations which these depots service. With still further expansion the system will be operated until 2 a.m. daily and eventually on a 24-hour-a-day basis. Facilities are now being completed for communication with the newest depot at Mobile, Ala.

"Advantage of the new system lies in the fact that the balances are received on Teletype tape, which is fed through a newly devised card punching machine which automatically records each new balance on a card, and is then filed automatically.

"Prior to the establishment of the new setup, the Air Corps kept check on its stock by a system of machine posting in duplicate of stock record cards at stations and depots. Once a year the duplicates were sent in to the materiel division headquarters at Wright Field, where they were transcribed to tabulating cards, which in turn were used for preparing reports for the supervisors for purchasing and distributing a new stock as required. The stock record cards were hand filed at the field headquarters prior to punching of tabulating cards.

"But the once a year balance became out of date so quickly after it was taken, that it proved to be to a large extent useless, except in normal peace times when there was no great fluctuation in requirements. The rapid pace of present Army Air Corps expansion soon found this system completely inadequate.

"The new card-punching machines, which operate automatically from the Teletype tape, were specially designed for this use on suggestion of the budget office, Wright Field, by the International Business Machines Corp., and the American Telephone and Telegraph Co."

Note: The machines were developed by IBM.

APPENDIX E

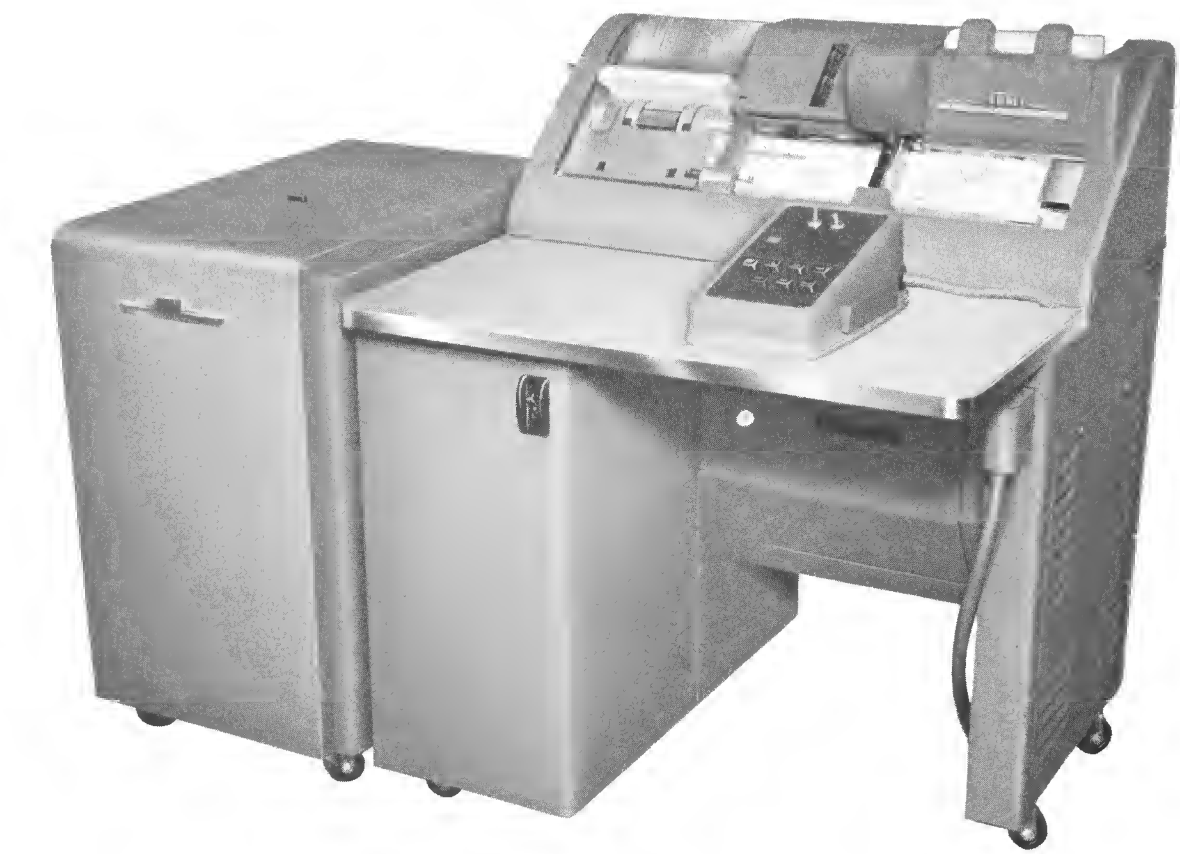
THE IBM 65 AND 66 DATA TRANSCEIVER TYPES (PRODUCTION MACHINE)

The IBM Data Transceiver provides a means of transmitting punched cards over wire lines (telephone and telegraph), microwave and short wave radio circuits. Two machines are necessary for such transmission, one to read the card data to be transmitted and the other to punch the data into a card at the receiving point. Because the Data Transceiver is able either to transmit or receive, one machine at each end of the circuit will provide transmission in both directions.

The transmission of data from card to card is direct, without storage or other intermediate steps such as the perforated paper tape. Because accounting data must be transmitted accurately, suitable checking circuits are incorporated to insure a high degree of accuracy in the transfer of data.

The design of the Transceiver is such that the receiving machine "supervises" the operation of the transmitting machine and the connecting circuit. In other words, the receiving machine operator must signal the transmitting machine operator before transmission can be started. This signal lights an indicator on the transmitting machine and conditions it to send the first card upon depression of its start key. Thereafter, as long as the receiving machine is "satisfied" with each card, the transmission and reception will proceed without interruption. Following the transmission of each card, the transmitter sends a special signal which, in effect, asks the receiving machine if it is satisfied with the card it has just received. If it is, a "go ahead" signal is sent back to the transmitter permitting it to send the next card. If the receiver is not satisfied with the card it has just received, it will not send the "go ahead" signal, and the transmitter will stop so that the card may be repeated. With this high degree of interconnection and other accuracy-checking facilities, cards can be put into the work stream as fast as they are produced by the receiver. Each card in itself represents a complete and checked transmission.

The Data Transceiver comprises a modified card punch and a Signal Unit which is contained in an auxiliary cabinet. The two units are connected by a multi-wire cable. The modified card punches are known as IBM 65 (when an IBM 24 non-printing punch is used) and IBM 66 (when an IBM 26 printing punch is used). The IBM 67 Signal Unit contains electronic circuits which transmit and receive the impulses over telegraph wires, and the IBM 68 Signal Unit contains electronic circuits which transmit and receive the impulses over telephone wires.



The IBM 66 Transceiver can Transmit or Receive Direct from Card-to-Card

When the Transceiver is in the transmit mode, the cards are read one column at a time; the readings are converted to the signaling code and then sent to the Signal Unit for transmission over the communication line. When the Transceiver is in the receive mode, the Signal Unit receives the impulses, sends them to the punch where the signaling code is converted to the IBM card code following which the data are punched into the cards. Numbers, letters, and IBM special character codes may be transmitted. Any other codes containing multiple punches, such as MLP codes, cannot be transmitted.

The start-stop method of signaling is used in the Transceivers. That is, the machines operate one character at a time and then stop until the start of the next character.

The electronic commutator operates through a 10-1/2 bit cycle to transmit a character. First, a synchronizing impulse is transmitted to start the receiving commutator. When signaling over telephone circuits, this synchronizing impulse is followed by eight code-bit impulses, four of which are transmitted with carrier tone on and four with the tone off. When signaling over telegraph lines or short wave radio circuits the characters are formed by operating a relay which makes and breaks direct current. The character

bits are followed by a stop interval which is in turn followed by the synchronizing pulse for the next character.

The machines will not operate unless the composition of every received character satisfies the fixed-count check. Character mutilation can be caused by interruption of a wire circuit (or fading signals on a radio circuit) or by crosstalk, noise, telegraph signals, and other types of interference on wire circuits (or static on radio circuits). Regardless of the cause, a character check will be signaled whenever a mutilated character is received, and the machines will stop for a repeat of the card being transmitted.

Character mutilations can be accepted only if one or more code bits are lost and then replaced by a corresponding number of bits to satisfy a valid code. Every code must represent an acceptable or valid character.

A chart showing all legitimate codes is on page 83.

Interconnection and Accuracy Checks

In addition to checking the composition of each character received, the machines stop for any of the following reasons:

1. Failure to read a character at the transmitter, provided the program card is properly punched

2. Failure to punch a character at the receiver, provided the program card is properly punched

3. Failure to punch the proper number of card columns at the receiver

4. Failure to skip the card accurately at the transmitter or receiver

5. Failure to feed a card at the receiver (or running out of cards, which to the machine is the equivalent)

6. Any interruption or interference on the transmission medium

7. Stacker of the receiver filled to capacity

8. If a signal is received while the receiver is duplicating or skipping.

THE TRANSMITTAL CODE CHART

CHAR-ACTER	CARD CODE	TRANSMITTAL CODE X	0	N	R	7	4	2	1
SPACE	—			■	■	■	■		
A	12-1	■	■		■				■
B	12-2	■	■		■			■	
C	12-3	■	■					■	■
D	12-4	■	■		■		■		
E	12-5	■	■				■		■
F	12-6	■	■				■	■	
G	12-7	■	■		■	■			
H	12-8	■	■			■			■
I	12-9	■	■			■		■	
J	11-1	■		■	■				■
K	11-2	■		■	■			■	
L	11-3	■		■				■	■
M	11-4	■		■	■		■		
N	11-5	■		■			■		■
O	11-6	■		■			■	■	
P	11-7	■		■	■	■			
Q	11-8	■		■		■			■
R	11-9	■		■		■		■	
S	0-2		■	■	■			■	
T	0-3		■	■				■	■
U	0-4		■	■	■		■		
V	0-5		■	■			■		■
W	0-6		■	■			■	■	
X	0-7		■	■	■	■			
Y	0-8		■	■		■			■
Z	0-9		■	■		■		■	

CHAR-ACTER	CARD CODE	TRANSMITTAL CODE X	0	N	R	7	4	2	1
&	12	■	■			■	■		
—	11	■		■		■	■		
0	0		■	■		■	■		
1	1	■	■	■					■
2	2	■	■	■				■	
3	3			■	■			■	■
4	4	■	■	■			■		
5	5			■	■		■		■
6	6			■	■		■	■	
7	7	■	■	■		■			
8	8			■	■	■			■
9	9			■	■	■		■	
$\overset{+}{0}$	12-0		■			■	■	■	
$\bar{0}$	11-0	■	■	■	■				
/	0-1		■	■	■				■
#	3-8				■	■		■	■
.	12-3-8			■		■		■	■
$	11-3-8	■				■		■	■
,	0-3-8		■			■		■	■
@	4-8				■	■	■		■
¤	12-4-8			■		■	■		■
*	11-4-8	■				■	■		■
%	0-4-8		■			■	■		■
START OR END OF CARD		■				■	■	■	
RESTART						■	■	■	■
TELEPHONE TELEGRAPH					■	■	■	■	
END OF TRANSMISSION				■		■	■	■	

This is a Fixed Count, Four of Eight Code

When the transmission of a card is completed, the transmitter sends the end-of-card signal of inquiry to the receiver, asking, in effect, if the receiver is satisfied with the card just punched. If the receiver is satisfied, it sends a "go ahead" signal back to the transmitter which permits it to send the next card. If the receiver is not satisfied, no "go ahead" signal is sent and after a few seconds delay the repeat lights glow on both machines. The transmitter cannot continue until the failure has been called to the attention of the operator at the receiver, who sends the "go ahead" signal manually by depressing the start key after he has recognized and corrected the situation. In most cases the operator at the transmitter makes the correction by repeating the card that caused the light to glow.

Cards received which satisfy all checks are automatically punched with a 12 in column 81 at the time of ejection. Incorrectly received cards are not punched in column 81.

The punch includes a cable-connected Control Unit which contains switches, keys, and signaling lights necessary to the proper operation of the machine. Switches include print control and send-receive. Keys include interlock, TEL, end-of-transmission (EOT), reset, start, feed and release. Lights include power, start, repeat, blank column, character check, TEL, EOT, and card check. Reference Manual on the 65-66 Data Transceiver includes a complete description of the functions and purposes of the switches, keys and lights.

Transmission on Telephone Lines

With the IBM 68 signal unit, the transmission is at the rate of 11 fully punched cards per minute for the IBM 65 punch unit and 10 cards per minute for the IBM 66 punch unit. If cards are punched with less than 80 columns, the number of cards obtained per minute increases almost proportionately to the lesser number of columns transmitted per card.

As Transceivers operate on any of four carrier frequencies, on either two-wire or four-wire telephone lines, up to four independent transmissions can be made simultaneously over the same telephone line, provided each independent transmission has its own Transceiver at each end of the line. When machines are to be used in multiple operations, they must be used in assigned pairs.

The carrier frequency is determined by a pluggable channel selector, which is accessible to the operator so that the machine can be changed from one channel to another. The carrier frequencies are 800, 1300, 1800 and 2300 cycles per second.

A 500 cps pass-band is used to pass signals keyed at the rate of 180 bits per second (5.55 milliseconds per bit).

In two-wire operation, the same filter is used alternately for transmitting and receiving. In transmitting, it serves to reduce the amplitude of higher-order side-band signals to prevent interference on adjacent channels. When used as a receiving filter, it will pass the desired carrier frequency and reject all others.

In four-wire operation, each channel selector contains two band-pass filters, one for transmitting and the other for receiving.

Use of the facilities for voice communication and card transmission is on an alternate basis, and a suitable switching arrangement is provided by the communications company.

Transmission on Telegraph Lines

Signaling characteristics of Transceivers for use on telegraph circuits are identical to telegraph printer signals in bit duration and in amplitude. However, the number of bits per character is 10.5 as compared to 7.42 for most telegraph machines. Make-break operation on either two-wire or four-wire circuits is provided. Transceivers are not equipped to send or receive polar signals.

Because of the difference in the transmission codes, Transceivers will not operate on circuits equipped with regenerative repeaters, and arrangements must be made to switch them out during card transmission. The built-in regenerative feature of the Transceiver eliminates the necessity for signal regeneration.

Over telegraph facilities, only one transmission can be made per telegraph line. The proper telegraph speed selector is plugged into the Signal Unit for the class of service available. With telegraph speed selector #60 for use on telegraph lines that transmit 60 words per minute, the effective output is approximately three 80-column cards per minute. With telegraph speed selector #75 for use on telegraph lines that transmit 75 words per minute, the output is approximately four 80-column cards per minute. With telegraph speed selector #100 for use on telegraph lines that transmit 100 words per minute, the output is approximately five 80-column cards per minute.

Use of the facilities for printer operation and card transmission is on an alternate basis, and an alternate-use switching arrangement is provided by the communications company.

Transmission on Radio Circuits

Transceivers may be operated over long-distance, short wave radio circuits which are suitable for telegraph printer operation, with the exception that channels derived by time-division multiplexing or channels which include re-

generative repeaters cannot be used because these devices will not accept the eight-element checkable code used by the Transceivers.

No changes in the radio equipment are required when the terminations are equipped for telegraph printer service. Radio transmission requires duplex circuits, with one channel for transmitting and one channel for receiving.

Microwave Circuits

In general, operation over these facilities will be satisfactory if they meet the standards of private-line telephone or telegraph-wire service.

Test Facilities

Test facilities have been incorporated in both the telephone and the telegraph Transceiver Signal Units for use in localizing trouble to the machine transmitting, the machine receiving, or to the transmission facility. Use of these facilities by machine operators results in more prompt clearing of a trouble, because service calls can be directed to the IBM office responsible for servicing the inoperative machine or to the communications company if line trouble is indicated. These facilities comprise neon lights and test switches. The neon lights flash to show the composition of characters transmitted and received. The test switch settings are described below.

On the IBM 68 Signal Units, setting the switch to LINE position will send a steady tone corresponding to the frequency of the channel selector in use. This test may be requested by the communications company representative for measuring line losses.

The following settings are provided on the IBM 67 Signal Units:

1. When the switch is set to Test 1 position, the machine will transmit reversals (mark-space or on-off signals) which will show on the neon indicating panels as Q, R, 4, 1. This signal may be requested by the communication company personnel for measuring circuit characteristics, or by an IBM customer engineer for checking the receiving machine.

2. When the switch is set to Test 2 position, the signal unit transmits pulses which will flash the neon indicators X, N, 7. When the alternate-use switch at the receiving location is set to PRINTER, this series of pulses should print 4's or R's continuously if the machines and the circuit are operating.


1940
1960